Regional Operational Plan SF.2A.2013.24

Susitna River Chinook and Coho Salmon Inriver Abundance and Distribution and Pink Salmon Spawning Distribution

by

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February 2014

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL OPERATIONAL PLAN SF.2A.2013.24

SUSITNA RIVER CHINOOK AND COHO SALMON INRIVER ABUNDANCE AND DISTRIBUTION AND PINK SALMON SPAWNING DISTRIBUTION

by

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Signature Page

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Approval

Title	Name	Signature	Date
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PURPOSE

The Alaska Energy Authority (AEA) has begun the planning process for the Susitna-Watana hydroelectric project, which would dam the Sustina River at river mile (RM) 184 (http://www.susitna-watanahydro.org/; Figure 1). Salmon stock assessment and habitat utilization studies are part of the permit application process, and AEA awarded the Alaska Department of Fish and Game (ADF&G) funds for Chinook, coho, and pink salmon studies in the Susitna River.

In 2013, the ADF&G plans to estimate the spawner distribution study for Chinook salmon to both the Yentna and mainstem Susitna rivers, and focus the spawner distribution studies for coho and pink salmon to the mainstem Susitna River only. Inriver Chinook salmon abundance estimates will be attempted for both the Yentna and mainstem Susitna rivers, while an inriver coho salmon abundance estimate will be attempted for only the mainstem Susitna River. The additional data will improve confidence in the spawning distribution and habitat use of the three species and quantify the variation in that use. The abundance estimate for Chinook salmon in the entire Susitna River (mainstem Susitna plus Yentna rivers) will be the first one attempted since the 1984 estimate for the Su Hydro project, and comes at a time when unusually low abundance is causing widespread concern. In addition to the permit application, these data will be useful for interpreting present and past stock assessments, choosing future assessments that are efficient and effective, providing new knowledge to fishery managers, users, and the BOF, and for land use planning and permitting.

OBJECTIVES

1. Identify Chinook, coho, and pink salmon spawning locations in the mainstem Susitna River, by tagging site (fish wheel or gill net), so that any spawning location used by at least 5% of the Chinook or coho spawners captured in a particular fish wheel will be detected (≥ 1 radio tag) with probability of at least 99%, and if spawners are distributed uniformly among 20 locations, the probability of detecting all 20 locations is at least 99%. Any spawning location used by at least 5.0% of the pink spawners captured in a particular fish wheel or Chinook spawners captured with a gill net will be detected (≥ 1 radio tag) with probability of at least 98%, and if spawners are distributed uniformly among 20 locations, the probability of detecting all 20 locations is at least 75%.
2. Identify Chinook salmon spawning locations in the Yentna River, by tagging site (fish wheel or gill net), so that any spawning location used by at least 5% of the Chinook spawners captured in a particular fish wheel will be detected (≥ 1 radio tag) with probability of at least 99%, and if spawners are distributed uniformly among 20 locations, the probability of detecting all 20 locations is at least 99%. Any spawning location used by at least 5.0% of the Chinook spawners captured with a gill net will be detected (≥ 1 radio tag) with probability of at least 98%, and if spawners are distributed uniformly among 20 locations, the probability of detecting all 20 locations is at least 75%.
3. Estimate the proportions of Chinook and coho salmon inriver abundance spawning in 15 major tributaries (or groupings of minor tributaries) of the mainstem Susitna River, such that each proportion is within ±12 percentage points of the true value 90% of the time.
4. Estimate the proportions of Chinook salmon inriver abundance spawning in 15 major tributaries (or groupings of minor tributaries) of the Yentna River, such that each proportion is within ±12 percentage points of the true value 90% of the time

5. Estimate the inriver Chinook salmon abundance in the Susitna River above RM 24:
   a estimate the abundance of Chinook salmon ≥500mm MEF in the mainstem above the mouth of the Yentna River such that the estimate is within 25% of the true value 90% of the time, and
   b. estimate the abundance of Chinook salmon ≥500mm MEF in the Yentna River such that the estimate is within 25% of the true value 90% of the time.
6. Estimate the inriver coho salmon abundance in the mainstem Susitna River above the mouth of the Yentna River such that the estimate is within 40% of the true value 90% of the time.
7. Estimate the age composition of Chinook salmon passing the weirs on the Middle Fork Chulitna and Talachulinta rivers and Montana and Lake creeks, such that each age class is within ± 7 percentage points of the true values 95% of the time.

SECONDARY OBJECTIVES

1. Collect a tissue sample for genetic analysis from all salmon marked with a radio tag.
2. Collect a tissue sample for genetic analysis from all Chinook salmon sampled for scales, and 200 coho salmon, at the Middle Fork Chulitna and Talachulinta rivers and Montana and Lake creeks.
3. Collect a scale sample and length from sockeye salmon captured in fish wheels at the mainstem Susitna tagging site.
4. Estimate the mean length-at-age of Chinook salmon passing the weirs on the Middle Fork Chulitna and Talachulinta rivers and Montana and Lake creeks.

METHODS

FUNDAMENTAL DESIGN

A two-event, capture-recapture experiment will be used to estimate the inriver abundance of Chinook salmon in the entire Susitna River, and the inriver abundance of coho salmon in the mainstem Susitna River. Only radio tags will be used to mark fish. Fish wheels and gill nets will be used for tag deployment while floating weirs and associated fixed radio receivers will be used for second event data collection. Tag deployment sites will be operated at two locations: one on the Yentna River (RM 6.2), and the second on the mainstem Susitna River at RM 30 (Figure 2). At each site, two fish wheels and gill nets will be operated. At the weir sites, all Chinook and coho salmon will be counted and radio tags will be recorded as tagged salmon migrate past a fixed radio receiver adjacent to each weir.

For the spawning distribution, all radiotagged salmon will be relocated using fixed tracking stations on major tributaries, stations located at weir sites, and repeated aerial surveys over the major tributaries (Figure 1).

SAMPLING METHODS

Marking Effort – Fish wheels and drift gill nets

Radio tagging of Chinook salmon will occur approximately 22 May to 30 June, 2013, and tagging of pink and coho salmon will occur approximately 7 July to 20 August, 2013. Tagging will begin when water levels and debris loads allow for safer operations of fish wheels and gill

nets. Fish wheels will be operated for 12 h/d each with two person crews (6 h/shift for 2 shifts; Appendix A1). At the Yentna and the Mainstem Susitna river sites, 2 crews will work 7.5-h shifts each day, to operate two fish wheels during daylight hours. The total effort for each fish wheel will be 12 h/d (6 h/shift for 2 shifts; Appendix A1). Each fish wheel will be operated every day of the season, except for breakdowns, crew shortages, or unsafe weather.

Fish wheels will be aluminum, with 2, 6-ft wide baskets that are webbed with knotless, nylon, 1.5-in mesh (square measure). Fish in the basket will descend an aluminum basket chute to a fabric slide across the float, and drop into the holding box. The holding boxes will be 8-ft long, 2-ft wide, and 3- deep, with plywood sides and holes cut to allow water exchange. The configuration of the fish wheel axle, baskets, and floats make the fishing depth a maximum of 6.5 ft. The fish wheels at Yentna have a maximum fishing depth or 4.5 ft. Fish wheels will be tied to the river bank and braced offshore with poles to position the wheels in sufficient current to make them spin. The axle height will be adjusted so that the baskets sweep as close to the river bottom as possible. A picket weir with 1.5-in gaps between pickets will be installed between shore and the fish wheel, to direct migrating salmon towards the fish wheel baskets.

In order to obtain a representative sample of all migrating Chinook salmon, fish wheel samples will be supplemented by drift gill nets fished offshore of the fishwheels. In 2012, Chinook salmon captured in gill nets had a larger average length than fish wheel captured wheels. Three drift net sizes will be used. Dimensions will be 5.5, 7 and 7.5 inch stretch mesh, 60 ft long and approximately 10-12 ft deep. The desired capture technique will be to entangle fish by the snout, to avoid injuries that gilling would cause.

A comparison of the length distributions of all Chinook salmon passing the Deshka weir and "recaptured" radio tagged fish past the weir indicated the 2012 sample of radio-tagged fish was biased toward smaller fish, with the first point for stratification occurring at 580 mm mid-eye to tail fork (MEF). A comparison the size distributions of all Chinook salmon captured with all gears at the mainstem tagging site and those past the Deshka weir indicates that fish < 580 mm MEF should be tagged at 1/3 the rate of larger fish to at least partially mitigate for size bias at the marking site.

All captured Chinook salmon will be measured. Initially, all uninjured Chinook salmon ≥ 580 mm MEF will be tagged and every third (1/3) Chinook salmon ≥ 500 MEF mm and < 580 mm MEF will be tagged. The nets will be fished until corks sink, indicating a fish is in the net, which will be immediately pulled in. One crew of two technicians will fish for up to 7.5 h/d, with start times rotating daily until a cycle is completed each week, to reduce bias due to the run timing of any individual stock (Table 1).

At the mainstem Susitna and the Yentna rivers, 700 Chinook salmon will be tagged at each site with radio tags. The target distribution for radio tags will be 300 per fish wheel and 100 from drift gill nets. At the Mainstem site only, 600 coho and 200 pink salmon ≥400 mm MEF will be tagged with a radio tag.

Fish will be radio tagged at each fish wheel and via gill net 7 d per week according to Table 2. Tags will be deployed systematically, given that a fixed number of tags are to be deployed. Tagging healthy fish as soon as they are captured should avoid selection bias by the crews.

If the scheduled number of radio tags for a given species cannot be deployed at a given wheel due to low catch that shift, the leftover tags will be deployed by the next shift, even if it is the following day. The next shift will deploy its regularly scheduled tags first, then the leftover tags. This will continue until the leftover tags are deployed, and the crew can get back on the original schedule. So that radio tags are deployed in proportion to the run, the number of tags deployed from each wheel may be adjusted depending on catch rates.

To minimize handling stress on all salmon, only salmon that have been held in the livebox <1 h will be radio tagged. Radio telemetry data for coho salmon in the Kenai River indicated that fish that were tagged immediately upon capture experienced a mortality rate half that of fish that were held for variable times in the fish wheel livebox before tagging (10% vs. 20% mortality, Carlon and Evans, 2007). Live box holding time for all fish radio tagged will be recorded. Preliminary results from identical holding time practices at Flathorn in 2010 showed minimal lingering tagging effects on most fish. After adjusting for tagging/handling loss (11% for chum, 12% for coho), upstream movement was detected in 91% of radio-tagged chum salmon and 86% of radio-tagged coho salmon within 1 day of release after tagging in 2010 (ADF&G, unpublished data).

Two person crews will process selected salmon quickly to reduce handling time. Fish will be in a holding tank onboard a boat during tagging. A bucket will be used to frequently add water to the tank. A padded, aluminum cradle (Larson 1995) will be slipped around the fish to restrain it during tagging. One person will restrained the fish, the second will insert a radio tag, and record data. Radio tags will be inserted through the esophagus and into the upper stomach of the fish using a 0.38 in (outside diameter), 12 in long plastic tube. The antenna of the radio transmitter will be threaded through the tube and pinched by hand at the end of the tube, such that the radio transmitter is held tightly against the opposite end of the tube. Chinook salmon <500 mm MEF will not be radio tagged because the large majority of such fish will likely be jacks. The size and weight of the radio tags used may have more impact on such small fish, as the radio tag could be about 1.6% of the body weight of a 400 mm MEF fish. Smaller radio tags will be used for pink salmon 400 to 420 mm MEF (see Data Collection below). The plastic tube will be marked with reference points to assist in proper tag insertion depths. Resistance felt during tag insertion will be the most useful indicator, and the esophagus will be visually inspected to ensure none of the tag body is visible. The crew will measure MEF and total length (TL) (Appendix A2), remove and preserve the distal 0.5 cm of the left axillary process (Appendix A3), and record the time taken to process the fish (Appendix B1).

Chinook, Coho and Pink Salmon Spawning Location

Movements of radio tagged fish will be monitored from time of release by a combination of aerial surveys and tracking stations at major tributaries and weir sites. Three tracking stations will be placed in the Yentna drainage and 5 tracking stations upstream of Susitna Station (Table 4, Figure 1). All tracking stations will consist of at least two antennas, a receiver/logger, and self contained power system. Radiotagged fish within reception range of the stations will be identified and recorded. Information collected will include the date and time the fish are present at the site, the signal strength and activity pattern of the transmitter (active or inactive), and the location of the fish in relation to the station (i.e., upriver or downriver from the site). Information on tracking station operations (i.e., voltage levels for the station components, and whether the reference transmitter at the site is being properly recorded) will also be collected.

The 8 tracking stations will be located on important migratory corridors and below spawning grounds on major tributaries.

A fixed wing aircraft will be used for aerial surveys. Two Yagi antennas, one on each side of the plane, will be mounted on a wing strut with the antenna oriented forward slightly downward, and the elements vertical, to maximize the reception. Both antennas will be combined into one line to the receivers. An ATS R4520C radio receiver/logger with an internal global positioning system (GPS) receiver will be programmed to continuously scan all frequencies and create a log of the tags detected and the concurrent latitude and longitude.

Tracking flights will be made approximately every 2 weeks from 15 June through 15 September to locate radio tagged fish, weather permitting. The flights will cover major tributaries throughout the entire Susitna drainage. Each transmitter will be located to approximately the nearest 1 rkm. Any transmitters signaling a mortality pulse will be noted. A handheld GPS, set to automatically record a track, will be operated for the full duration of each flight to document the extent of each survey.

For all salmon species, the radio transmitters will be manufactured by Advanced Telemetry Systems, Inc. (ATS^{TM}) and will operate on several frequencies within the 150.000 - 151.999 MHz range. Each frequency (22 total) used will have 100 pulse codes resulting in 2,200 uniquely identifiable transmitters. Each transmitter will be equipped with a mortality indicator mode that activates when the tag is motionless for approximately 24 h. All Chinook salmon will receive the ATS F1845B transmitters, which will be 52-mm long, 19 mm in diameter, have a mass of 26 g, have a 30-cm external whip antenna, and a nominal battery capacity life of 311 d. This means they could operate until at least early March 2013, actual battery life will be determined once the options are programmed. Pink salmon <420 mm MEF will receive the ATS F1835B transmitters, which will be 48-mm long, 17 mm in diameter, have a mass of 16 g, have a 30-cm external whip antenna, and a nominal battery capacity life of 185 days. All other salmon will receive the ATS F1840B transmitters, which are 56-mm long, 17 mm in diameter, have a mass of 20 g, have a 30-cm external whip antenna, and a battery capacity life of 126 days.

Recapture events

Weir and Fishwheel Operations

Floating weirs will be operated at five sites to count and sample Chinook salmon. Two weirs will be operated in the Yentna River drainage at Lake Creek and the Talachulitna River and three in the Susitna River drainage at the Deshka River, Montana Creek and the middle fork of the Chulitna River. At all weir sites fixed radio tracking stations will be installed to record the radio frequency and pulse code of tagged Chinook salmon as they migrate past the weir. Daily counts of Chinook salmon migrating through the weir will be recorded on forms and reported to the Palmer office. Radio receiver/loggers will be checked periodically to confirm their proper operation and to download data. At each weir site, genetic samples will be collected from Chinook salmon via a trap placed on the weir or by seine netting. Other species counted through the weir will be tallied on forms at camps and reported to the Palmer office.

Second event sampling data will also be collected by LGL, Inc. at fishwheels operated in the Susitna River near Curry. All Chinook salmon captured will be examined for the presence of a radio tag and length (MEF) data will be collected. All Chinook salmon examined at Curry that

do not contain radio tags will be marked with a dart tag so that they can be uniquely identified if encountered at any weir sampling sites.

Sonar Operations

On the Talachulitna River and Lake Creek we plan to operate floating weirs for the duration in the Chinook salmon season. In the event that water levels prevent weir operation, sonar units will be used to count migrating Chinook according the protocol below. A partial rigid weir will be installed on each bank to force migrating Chinook salmon offshore and within the range of the sonar transducer.

Fixed-location, side-looking sonar techniques are commonly used to obtain in-season estimates of run strength for anadromous fish stocks in rivers that are too wide for installing weir structures or too occluded for visual observations (Daum and Osborne 1998; Enzenhofer et al.1998; Gaudet et al. 1990; Maxwell and Gove 2007). In Alaska, sonar estimates of inriver passage often provide the basis for estimating spawning escapement and for regulating harvests of commercially important salmon stocks (Westerman and Willette 2006; Miller et al. 2010). Acoustic assessment sites currently exist on at least ten rivers in Alaska. One of the barriers to wider use of sonar assessment has been the need to estimate the number of spawning salmon separately by species. Apportioning sonar counts by species often requires separate intensive sampling programs such as netting programs (Bromaghin 2005; Carroll and McIntosh 2008) or fish wheel programs (Fair et al. 2009) that are costly to implement and subject to biases that can be difficult to resolve.

Apportioning sonar counts by species during 2nd event sampling for these experiments will be relatively simple. For any instances where sonar is used prior to 7 July 2013, it is extremely unlikely that passage by any species other than Chinook salmon will be occurring, based on passage records of sockeye, chum, coho and pink salmon at the Flathorn, Yentna, and mainstem Susitna fishwheel sites. Virtually all salmon ≥ 700 mm MEF passing any 2nd event sampling site will be Chinook salmon, and the ratio of Chinook salmon 500m-699 mm MEF to those ≥ 700 mm MEF at the mainstem sampling sites in 2012 was fairly stable after the 2nd week of sampling ($p = 0.36$ using contingency table analysis), though tending to decrease over the course of the run. Estimates of the length composition of salmon passing sonar when sonar is operating will be converted from DIDSON measured lengths to TL to MEF and the relationship between Chinook salmon 500m-699 mm to those ≥ 700 mm MEF at that site will be used to estimate Chinook passage if other species are present (see Data Analysis).

The Adaptive Range Imaging Sonar (ARIS) is the most recent DIDSON technology developed and manufactured by SMC. ARIS has several advantages over current DIDSON technology; it has user configurable window lengths (no longer restricted to discrete lengths) and improved downrange resolution (from 512 pixels to 4048 pixels). Additionally, ARIS is a "sealed" system which should negate the need for using a "silt-excluding enclosure" to protect the system from silt buildup inside the lens cavity. The "silt socks" currently used to exclude silt have resolved the issue for the most part, but the "socks" are relatively fragile and can be breached easily if the system is subjected to impact with debris or the bottom during deployment and/or retrieval. These silt socks are not commercially available through the manufacturer but instead must be custom manufactured.

MARK RECAPTURE:

Abundance - Assumptions and Testing

These two-event closed population mark-recapture experiments are designed so that a Petersen-type estimator may be used to estimate abundance of Chinook and coho salmon. For these estimates of abundance to be unbiased, certain assumptions must be met (Seber 1982). These assumptions, expressed in the circumstances of this study, along with their respective design considerations and test procedures will be that:

Assumption I: The population is closed to births, deaths, immigration and emigration.

Considering the life histories of these Chinook and coho salmon, there should be no recruitment between sampling events. First event sampling (marking) will begin prior to any significant passage of fish past the tagging sites and will continue through the run until passage has dropped to near zero.

Assumption II: There is no trap induced behavior.

There is no explicit test for this assumption because the behavior of unhandled fish cannot be observed. We will attempt to meet this assumption by minimizing holding and handling time of all captured fish. Any obviously stressed or injured fish will not be tagged. Examples would be fresh seal bites that penetrate into the muscle, capture injuries such as torn opercula, large skin wounds or broken snouts, or being dropped in the boat while tagging.

Assumption III: Tagged fish will not lose their marks between sampling events and all marks are recognizable.

Tag loss will be estimated for the abundance experiment. Chinook sampled at weir site will be examined for missing axillary fine indicating a radio tag has been regurgitated or otherwise lost.

Assumption IV: One of the following three conditions will be met:

- All Chinook and coho salmon will have the same probability of being caught in the 1st event, or
- All Chinook and coho salmon will have the same probability of being captured in the 2nd event; or,
- Marked fish will mix completely with unmarked fish between samples.

In this experiment, it is unlikely that marked and unmarked fish will mix completely. Fish wheels will be operated continuously during the run, however probabilities of capture of both Chinook and coho salmon may change as their annual migration progresses. Fluctuations in water levels at 1st event sampling sites can affect the efficiency of fish wheels, resulting in variation in probability of capture over time. Also, the probabilities of capture will likely vary between fish wheel sites during the1st event due to differences in channel morphology and water flow (Yanusz et al. 2007).

Use of weirs for 2nd event sampling will not provide a simple random sample of all fish upstream of the tagging site. All salmon destined to spawn above our weir sites have a probability of being sampled approaching 1.0, while fish spawning elsewhere have a 0.0 probability of being sampled at a weir during the 2nd event. While the 2nd event sampling is not random, it will not necessarily provide a biased estimate of the marked:unmarked ratio. The diagnostic tests described below will

identify appropriate remedial measures for departures from the conditions above and direction is selecting the most appropriate model(s) to estimate abundance.

Equal probability of capture will be evaluated by time, area, and size. The procedures to analyze length data for statistical bias due to gear selectivity are described in Appendix D1. If different probabilities are indicated, data will be fully stratified into size groups where probability of capture is homogeneous within groups, and abundance estimates will be calculated for each size group and summed. .

Contingency table analyses recommended by Seber (1982) and described in Appendix D2 will be used to detect significant temporal or geographic violations of assumptions of equal probability of capture. The test for complete mixing (Test I in Appendix D2) will not be performed. We expect the complete mixing condition will be violated geographically because a strong tendency for bank orientation by coho salmon at the Flathorn tagging site was demonstrated during the 2009 and 2010 radio-telemetry studies (Merizon et al. 2010, Cleary et al. 2013.) Examination of Chinook salmon data collected in 2012 suggested some bank orientation at the mainstem tagging sites by Chinook salmon spawning above the Deshka weir, as a larger proportion of west bank captured fish entered the Deshka River than east bank captured fish ($p = 0.21$). The complete mixing condition cannot be satisfied temporally, due to experimental design and the time of movements of fish being investigated. If the test for equal probability of capture during the 1st event (Test II) does not detect significant departure from this condition, this will likely be a result of: a) while variation in probability of capture occurred, it was not extreme; and b) some partial mixing does occur between sampling events to the extent necessary to buffer the effects of variation in probability of capture during the 1st event. Based on previous experience, it is anticipated geographic and possibly temporal violations of these assumptions will be detected, and a Petersen-type model would yield a biased estimate. Therefore, abundance will most likely be estimated using models developed by Darroch (1961) for a two-event mark-recapture experiment on a closed population when temporal or spatial distributions of fish affect their probabilities of capture.

SAMPLE SIZES

Abundance

Assessment of sampling effort necessary to achieve our precision criteria for Objective 1 will be based largely on experience gained during the 2010-2012 experiments. We expect sampling rates (the proportions of the population passing each sampling site that are captured) will be similar in 2013 to what was experienced in previous years.

We determined the necessary sample sizes to meet the precision criteria in Objective 1 based on several assumptions about the outcome of our sampling efforts. This experiment is designed so that if all necessary experimental assumptions are met, an unstratified Petersen-type model could be used to estimate abundance of both Chinook and coho salmon. The approach of Robson and Regier (1964) was used to provide necessary sample sizes for a given population size and precision criteria. The interpretation of these sample size numbers was modified to accommodate mitigation for violations of necessary assumptions that we expect will be necessary for this experiment.

We expect that a Darroch (1961) model, rather than a Petersen-type model, will be necessary to estimate abundance of Chinook and coho salmon as a result of uncontrollable geographic and

temporal variation in probability of capture during the experiment. In reviewing several salmon mark-recapture experiments where a Darroch-type model was required to estimate abundance, we observed that the unbiased CV for abundance estimates was 1.3 to 2.3 times as large as it might have been if necessary assumptions were satisfied and a Petersen-type model were appropriate. In 2010, the CV of our estimate of chum salmon abundance based on a Darroch model with correction for handling loss was approximately 1.6 times larger than would have been realized using a Chapman estimator with no correction for handling loss for a similar size population size and sampling effort. Similarly, the CV of our coho salmon abundance estimate based on a Darroch model with correction for handling loss was approximately 2.0 times larger than provided by a Chapman model.

For these experiments we assumed that the CV's of our final estimates of abundance using the Darroch model, will be 2 times as large as we would see if no adjustments were necessary and a Petersen-type model were appropriate. The methods of Robson and Regier (1964) were used to calculate the necessary sample sizes, for different potential population sizes, to estimate abundances of Chinook salmon in the Yentna River drainage and in the Susitna River drainage above the mouth of the Yentna River within 12.5% of the true values 90% of the time with a Petersen-type model. We expect that these same sample sizes will allow us to estimate abundances of Chinook salmon within 30% of the true values 90% of the time, after mitigating for violations of assumptions as described above. Based on results of the 2012 radio-tagging experiment, we expect ~25% of the fish radio-tagged at the mainstem wheels will be censored from the experiment because ~ 15% will not be detected at all or will only be detected downstream of the tagging site plus up to 10% will spawn in the Yentna River system. We expect ~15% of the fish radio-tagged at the Yentna wheels will not be detected at all or will only be detected downstream of the tagging site. As the Yentna wheels are located 8 miles upstream of the mouth, we expect losses do to fish spawning in the mainstem to be negligible.

Similarly for mainstem coho salmon, he methods of Robson and Regier (1964) were used to calculate the necessary sample sizes, for different potential population sizes, to estimate abundance within 20% of the true value 90% of the time with a Petersen-type model. We expect that these same sample sizes will allow us to estimate abundances of coho salmon within 40% of the true values 90% of the time, after mitigating for violations of assumptions as described above by using a Darroch (1961) model. Based on results of our 2010 – 2012 experiments, we expect ~15% of the coho salmon radio-tagged at the mainstem wheels will not be detected at all or will only be detected downstream of the tagging site.

The minimum sample size requirements, and numbers of Chinook salmon expected to be sampled during 1st and 2nd event sampling for potential population sizes from 20,000 to 120,000 are presented in Table D2-1. Using the 2012 radio-tagging data and treating the Deshka River weirs as a 2nd event sampling site, a (biased low) Petersen estimator suggests the number of Chinook salmon spawning above the mainstem tagging site was on the order of 40,000 to 80,000 fish ($\hat{N}$ ~ 58,000). Also, approximately 33% of the mainstem deployed radio-tags were detected above the Deshka River, Montana Creek, and Chulitna River weir sites or at the Curry fishwheels operated by LGL. For the mainstem Chinook experiment, we need to inspect ~ 25% of the spawning population above the mainstem tagging site during 2nd event sampling to achieve the precision criteria for Objective 5a (Table D2-1), so our sampling design is expected to be adequate. Based on sums of midrange Yentna and mainstem aerial survey escapement goals and expert opinion (Dave Rutz, personal communication) we expect the 34-40% of the spawning

Chinook salmon in the Sustina River system upstream of Flathorn to spawn in the Yentna River, suggesting a spawning population on the order of 20,000 to 60,000 fish. We have no objective data about the proportion of Chinook salmon in the Yenta River that spawn in Lake Creek and the Talachulitna River. However, these two systems are the two systems in the Yentna where aerial survey index counts are conducted annually for Chinook salmon and, for this experiment, we assume that they will contain in excess of 30% of the spawners. For the Yentna River Chinook experiment, we need to inspect ~ 22.5% of the spawning population above the Yentna tagging site during 2nd event sampling to achieve the precision criteria for Objective 5b (Table D2-1), so our sampling design is expected to be adequate.

The minimum sample size requirements, and numbers of coho salmon expected to be sampled during 1st and 2nd event sampling for potential population sizes from 20,000 to 120,000 are presented in Table D2-2. The spawning distribution estimates from the 2010 coho experiment (Cleary et al. 2013) suggest that ~ 9% of the coho salmon spawning in the mainstem spawned in the Deshka River and Montana Creek drainages. The preliminary 2012 results suggest ~12% of the mainstem spawners were in these two systems where 2nd event sampling for coho will be conducted. Abundance estimates from thes 2010 – 2012 experiments suggest a population on the order of 80,000 to 120,000 coho salmon. We need to inspect ~ 12% of the spawning population above the mainstem tagging site during 2nd event sampling to achieve the precision criteria for Objective 5a (Table D2-1). so our sampling design will be adequate if spawning distribution is similar to what was estimated in 2012.

Chinook, Coho and Pink Salmon Spawning Location

For pink salmon, the project can afford 100 radio tags per fish wheel and we expect ~ 15% mark loss: using a Poisson model and assuming 20 spawning locations (aggregations of individual final radio tag locations), then any spawning location used by at least 5% of the spawners passing a fish wheel tagging site will be detected (≥ 1 radio tag) with probability of 98.6%, and if spawners are distributed uniformly among 20 locations, the probability of detecting all 20 locations is 75.0%.

For pink salmon, sample of 85 radio tags per fish wheel, applied proportional to run strength throughout the run, will be sufficient to meet the conditional precision criteria described in Objective 1. By deploying 100 tags per fish wheel, losses due to regurgitation or handling mortality of up to 15% will still allow meeting the objective criteria as long as tag loss is independent of spawning location. Independence will be assumed as it cannot be tested for with this experimental design. If catches at any one fish wheel are so low or tag loss is so high that 85 tags cannot be tracked to spawning sites, the stated criteria will not be achieved for that fish wheel.

For Chinook and coho salmon, the project can afford 300 radio tags per fish wheel at RM 30 and we expect a 15% mark loss: using a Poisson model and assuming 20 spawning locations (aggregations of individual final radio tag locations), then any spawning location used by at least 5% of the spawners passing a fish wheel tagging site will be detected (≥ 1 radio tag) with probability of > 99%, and if spawners are distributed uniformly among 20 locations, the probability of detecting all 20 locations is > 99%.

For Chinook salmon, a sample of 255 radio tags per fish wheel, applied proportional to run strength throughout the run, will be sufficient to meet the conditional precision criteria described in Objectives 1 and 24. By deploying 300 tags per fish wheel, losses due to regurgitation or handling mortality of up to 15% will still allow meeting the objective criteria as long as tag loss is independent of spawning location. Independence will be assumed as it cannot be tested for with this experimental design. If catches at any one fish wheel are so low or tag loss is so high that 255 tags cannot be tracked to spawning sites, the stated criteria will not be achieved for that fish wheel.

For Chinook salmon, a sample of 85 radio tags captured by gill net, applied proportional to run strength throughout the run, will be sufficient to meet the conditional precision criteria described in Objectives 1 and 2. By deploying 100 tags by gill netting, losses due to regurgitation or handling mortality of up to 15% will still allow meeting the objective criteria as long as tag loss is independent of spawning location. Independence will be assumed as it cannot be tested for with this experimental design. If gillnet catches are so low or tag loss is so high that 85 tags cannot be tracked to spawning sites, the stated criteria will not be achieved.

Chinook and Coho Salmon Spawning Distribution

Using the recapture data (radio tags in Chinook and coho salmon), variation in marked proportion among marking sites or over time can be tested, and an unbiased estimate of spawner distribution calculated if variation is not too severe. Prior to correcting for variation in probability of capture (assuming uniform probability of capture), the expected sample sizes of radio tagged Chinook salmon in mainstem Susitna River and Yenta River experiments (595 assuming 15% tag loss) are greater than the 403 required to estimate the proportions of Chinook salmon traveling to different spawning locations such that each estimated proportion is within ±5 percentage points of the true values 90% of the time (Thompson 1987). For radio-tagged coho salmon in the mainstem Susitna River, the expected sample size of 510 (assuming 15% tag loss) also excees the 403 required to estimate proportions of salmon traveling to different spawning locations.

Diagnostic tests for model selection for estimating abundance will provide evidence of potential geographic (between fish wheels) or temporal variation in probability of capture during the marking event, providing adequate direction for specifying a model or models for estimating abundance of fish passing the tagging sites by temporal and/or geographic strata based on probability of capture. Thus, groups of tags within strata can be properly weighed by estimates of the abundance of fish passing the tagging sites within strata. These weighted observations can be combined (see Data Analysis section) to provide unbiased or minimally biased estimates of the proportions of Chinook and coho salmon spawning in different tributaries.

Projecting the precision of estimates of proportions based on weighted tag observations, as described above, is very difficult. Empirical results from our 2010 – 2012 chum and coho salmon experiments provide an indication of the precision we might expect to see for spawning distribution for these 2013 Chinook and coho salmon experiments. For chum salmon in 2010, the value in the longer tail of a 90% credible interval deviated from the point estimates by < 10 percentage points in 14 out of 15 proportions estimated. For coho salmon, the deviation was < 10 percentage points in only 10 out of 15 proportions estimated, and was < 12 percentage points in 14 out of 15 estimates. Preliminary results from the 2011 and 2012 experiments are similar.

As our expected sample sizes for the 2013 experiments will exceed those realized for both chum and coho salmon in the 2010 – 2012 experiments, we expect the precision criteria for Objectives 3 and 4 will be achieved.

Chinook Salmon size and age composition

Asssuming 25% of scales are unreadable at each weir site, a sample of 347 Chinook salmon will be required at each weir to achieve the precision criterion for Objective 7 (Thompson 1987). The planned sampling rate of 350 salmon will be adequate.

Length composition data from these samples will be used to estimate the proportions of Chinook salmon ≥ 500 mm MEF passing each weir site, to estimate the size of the 2nd event samples for the mark-recapture experiments. These data may also be used to estimate proportions of Chinook salmon in different size strata, should size stratification be required. A sample size of 354 would be required to estimate multinomial proportions within 6 percentage points of the true values 95% of the time – level of precision sufficient to provide a small decrease in precision for the mark-recapture experiments given the other sources of uncertainty.

DATA COLLECTION

The Division of Sport Fish crew will provide a daily catch, effort, and radio tagging summary, environmental conditions, and any operational changes to a biologist at the Palmer Division of Sport Fish office at 1000 hours via telephone 5 d/week. Weir crews will report data daily to the Palmer office at a time to be determined. Division of Commercial Fisheries-Soldotna will operate the Yentna fish wheel and gill net sampling. Yentna crews will maintain daily contact with the Soldotna ADFG office, which will relay the above data to Palmer Division of Sport Fish daily on weekdays.

ABUNDANCE

Marking Event

Fish wheel catch and effort by shift will be recorded on the 2013 Catch and Effort data form. The form will be filled out with: date, crew initials, total fish wheel operation time, shift, start and stop times, crew arrival and departure time and the total number of Chinook, coho and pink salmon tagged and untagged (Appendix B2). In addition, the total number of other species captured for the shift will be recorded. At the Mainstem and Yentna River sites, radio tags will be deployed in 700 Chinook salmon at each site. This will be 300 per wheel and 100 via gill net per site. At the Mainstem site only, radio tags will be deployed in 600 coho (300 per wheel) and 200 pinks (100 per wheel). Initially, all uninjured Chinook ≥ 580 mm MEF will be tagged and every third (1/3) Chinook salmon ≥ 500 mm MEF and < 580 mm MEF will be tagged. The radio-tag deployment rates for Chinook salmon and the schedules for pink and coho salmon may be adjusted in-season depending on catch rates.

A total of 6 people will be used at the mainstem Susitna River site: 2 crews of 2 to run the fish wheels for 2 shifts each day, and 1 crew of 2 to sample with drift gill nets, in a split shift. At the Yentna River site, at total of 4 people will be used to staff the shifts described above.

The number of radio tags deployed each day for pink and coho salmon will occur according to a daily schedule. The schedule for Chinook salmon will be used as a guide to adjust the tagging rate.

Each fish wheel will be operated for 12 hr total each day, in two, 6-hr shifts. A shift will begin when the live box door is installed to hold captured fish. The first shift will begin at 05:00 and will end at 11:00. The live box door will be pulled after the first shift and replaced at 14:00 (when the second shift begins) and end at 20:00. A crew of 2 people will be on a shift. The radio tags will be evenly split between the first and second shifts, with odd numbers of tags alternating between the shifts. Pink salmon 400-420 mm MEF will radio tagged with a model F1835B radio tag (small). Pink salmon >420 mm MEF will radio tagged with a model F1840B radio tag (regular size). Equal numbers of pink salmon will be tagged with the two sizes of tag. In order to minimize fish wheel injuries, closed-cell foam padding will be placed where appropriate to prevent injuries as fish exit fish wheel basket chutes. In 2012 padding was placed along the edges of the live box and on the edges of the live box slide.

Fish wheel operations:

1. Each fish wheel will be visited every 1 hr or less. When a fish wheel has been untended for >1 hr, all the fish in the live box shall be counted, measured if due, and released, *but not radio tagged.*
2. The first *n* (where *n* = the number of radio tags to be deployed for the shift) coho and pink salmon >400 mm without fresh/recent injuries and having not fallen in the boat, will be placed in a water-filled tote with a cradle and tagged with a radio transmitter.
3. No tagging will occur without first placing the fish in water.
4. For every radio tagged fish, the distal 0.5-in of the left axillary process will be removed and preserved in a uniquely-numbered vial with ethanol.
5. All Chinook salmon (both radio tagged and not tagged) will be measured for MEF and TL, and only radio tagged coho and pink salmon will be measured for MEF.
6. Fish that are bleeding will measured and released.
7. Untagged coho and pink salmon will be tallied and released.
8. Once the radio tags for a shift have been deployed, the fish wheel will continue to be operated until the end of the shift.
9. Other fish species will be tallied on the data form and the fish released.
10. If the *n* radio tags scheduled for a shift cannot be deployed to low catches, those tags shall be deployed on the next shift(s).
11. To start the season, every healthy Chinook salmon ≥ 580 mm MEF will be tagged and every third (1/3) Chinook salmon ≥ 500 mm MEF and < 580 mm MEF will be tagged. The actual number of tags deployed will be compared to the scheduled number to be deployed every 5 d (Table 2), on 29 May, and 3,8, 13, and 18 June, in order to adjust the tagging rates if tags are being deployed too quickly. If tags at a particular fish wheel are being deployed too slowly (i.e., the tag surplus keeps building), the surplus may be reassigned to another fish wheel or the gill nets in order to utilize all tags by 30 June. Tags will not be shared between the mainstem Susitna and Yentna rivers.

12. To start the season, *n* will follow Table 3 for coho salmon at the mainstem Susitna River site. The actual number of tags deployed will be compared to the scheduled number to be deployed at each fish wheel every 5 d, on 13, 18, 23, and 28 July and 2, 7 August, in order to decrease *n* if tags are being deployed too quickly. If tags at a particular fish wheel fall behind schedule (i.e., the surplus tags keep building), the surplus may be reassigned to the other fish wheel in order to utilize all tags by 20 August.
13. To start the season, *n* will follow Table 3 for pink salmon at the mainstem Susitna River site. The actual number of tags deployed will be compared to the scheduled number to be deployed at each fish wheel every 5 d, on 17, 12, and 17 July and 1, 6 August, in order to decrease *n* if tags are being deployed too quickly. If tags at a particular fish wheel fall behind schedule (i.e., the surplus tags keep building), the surplus may be reassigned to the other fish wheel in order to utilize all tags by 16 August.

Drift net operations:

Drift gill netting will take place mid-channel and between the fish wheel sites to sample Chinook salmon not susceptible to fish wheel capture. Gill nets will also provide the opportunity to sample different size Chinook salmon, as fish wheels may be selective for smaller fish (Smith *et al.* 2009).

Prior to using new drift nets, old nets will be used to practice drift fishing and locate fishing sites that do not have snags. Four new drift net types will be used in 2013, each 60 feet long. Net dimensions are: 7.5 inch mesh, 10 to 12 foot depth, 7.5 inch mesh 15-17 foot depth, 5.5 inch mesh, 10 to 12 foot depth and 5.5 inch mesh 15-17 foot depth. Drift locations, duration, and net depth will be changed accordingly to depth or when net snags are found at fishing sites. One mesh size will be used per shift, and each shift will use a different mesh size, such that over the course of three shifts, each mesh size will be fished once, and then the pattern will repeat.

The desired capture technique will be to entangle fish by the snout, to avoid injuries that gilling may cause. The net will be watched continuously until corks sink, indicating a captured fish, then the net will be pulled in immediately. Two technicians will make as many drifts as possible during 7.5 h/d. To reduce bias due to the run timing of any individual stock, the effort will be split into two shifts, with the start time of each shift rotating 1 h/d until a cycle is completed each week (Table 1). After the *n* radio tags are deployed for each shift, drift net operations will cease. During the early part of the season, most of a shift will be spent fishing. However, when catches increase, radio tags will be deployed in the beginning of the shift. After radio tags are deployed for each shift, crews will be assigned other tasks to complete their shift.

Salmon captured in drift nets and will be processed as follows:

1. Net type (depth) will be used according to the conditions at drift sites.
2. Mesh sizes will be changed each shift.
3. Drift nets will be fished between the fish wheel sites and mid-channel.
4. Captured Chinook salmon will be immediately removed from the net and placed in a tote with water.

5. Chinook salmon >500 mm MEF length that do not have fresh/recent injuries and have not fallen in the boat will be placed in a cradle in a water-filled tote, and tagged with a radio transmitter.
6. Radio tagging will occur according to a tagging rate, initially set at every uninjured Chinook ≥ 580 mm MEF and every third (1/3) Chinook salmon ≥ 500 mm MEF and < 580 mm MEF. As above, radio tags will be applied to the first *n* (where *n*=the number of radio tags to be deployed for the shift) uninjured fish captured in each shift.
7. The distal 0.5 cm of the left axillary process will be excised and preserved from every radiotagged Chinook salmon for later genetic assay.
8. All other captured Chinook salmon (injured/ releqeased) will be measured in MEF and TL lengths.
9. If the *n* radio tags scheduled for a shift cannot be deployed to low catches, those tags shall be deployed on the next shift(s).
10. Other fish species will be tallied on the data form and the fish released.

Recapture Events

Weir Sites

Crews at the Middle Fork Chulitna and Talachulitna rivers, and Montana and Lake creek weirs will record data on a 2013 Chinook Weir daily reporting form (Appendix B2): day, date, total count, other species, and crew member initials. Tasks will be as follows:

a. Count and record all Chinook salmon and other salmon species through the weir.
b. Note dart tagged fish record dart tag information if possible
c. Measure 350 Chinook MEF and TL (to the nearest 5 mm) and collect three scales from the same fish (Appendix C). Every *n*th Chinook salmon will be sampled at each weir, according to Table 5, to achieve proportional sampling throughout the run. *n* was calculated using the escapement goal for each stock determined from aerial surveys. Unpublished ADF&G studies indicate roughly half of the escapement is observed on a single aerial survey during the peak spawning period. To be conservative, the lower end of the escapement goal was doubled to estimate the expected run. The sampling rate will be adjusted at each quartile of the expected Chinook salmon run to (each week in June) to achieve exactly 350 samples.
d. Ensure fixed radio stations have power and are scanning.
e. Record water level and temperature, and cloud cover.

Sampling at the Deshka River weir is being conducted by an independent project, and will follow similar methods in a separate operational plan (Hayes, ADFG Palmer, personal communication).

Sonar operations:

Sonar Deployment

Sampling will be controlled by electronics housed in a tent located on bank of the river. The ARIS will be mounted on remote pan and tilt systems (a Remote Ocean Systems PT-25 pan and tilt unit on the right bank, and a Sound Metrics Corporation X2 on the left bank) for precise aiming in the horizontal and vertical axes. The combined sonar and rotators will be deployed in the river on a tripod-style mount. In the horizontal plane, the sonar will be aimed perpendicular to the flow of the river current to maximize the probability of insonifying migrating salmon from a lateral aspect. Internal attitude sensors in the ARIS will provide measurements of compass heading, pitch, and roll. An AIM 2000 attitude sensor attached to the bank mount will provide depth measurements throughout the season.

Communication cables from feed directly into the right bank Top Side Box and data collection computer.

Sampling Procedures

A rigid weir will be installed on each bank to force salmon through the esonified zone. The ARISwill be positioned to record all images of salmon passing the gap between the rigid weir paneal. Images will be recorded 24 hours a day, 7 days a week. When counts are missing, the missing values will be treated as though they occurred randomly and the existing data will be expanded accordingly.

Data Acquisition

The transmit power of the sonar is fixed and the maximum receiver gain (-40 dB) will be used during all data collection. The lens focus to the mid-range of the gap between the weir panels.

Data Storage

One laptop will be dedicated to collecting data. To ensure correct time stamps in the filenames, the laptop clock will be synchronized using GlobalSat BU-353 Waterproof USB GPS receivers. Data will initially be collected by the host computer hard drive and subsequently transferred to two 1 TB external hard drives (two redundant copies) for permanent archiving at the site. Data transfer to the Palmer office will occur using 32 GB Jump drives. In the Palmer office data will then be transferred to an 8 TB where it can be shared with up to 7 users through a 1 GB Ethernet network (i.e. through an 8 port 1 GB Ethernet switch and 1 GB Ethernet cards in each computer).

Manual DIDSON-based Fish Length Measurements

Estimates of fork length will be made from images using the manual fish-measuring feature also included with the SMC DIDSON Control and Display software. Collaborative efforts with SMC have resulted in a reasonably efficient method of manually measuring individual fish. During the 2013 season, efforts will be made to manually measure all fish with length exceeding approximately 400mm. Detailed instructions for taking manual measurements and the software settings and parameters used are given in Appendix E

Seining at Sonar Sites

Seining will be conducted three times per week (Monday, Wednesday Friday) to detect upstream passage of salmon species other than Chinook for sonar deployed after 1 July 2013. For each day seining, four seine hauls will be completed. The seining will occur at the closest logistically

feasible site in the vicinity of the sonar site. ASL data and a genetic samples will be collected from Chinook and coho salmon, while others species will be enumerated.

GENETICS SAMPLES

The tissue samples from each radio tagged Chinook, coho, pink salmon will be placed in a uniquely-numbered vial (the radio tag number) and preserved in ethyl alcohol. The radio tag number will be used to link the spawning location and genetic data for individual salmon. These samples will be archived for use in possible future genetics studies. All salmon samples and relevant collection data will be shipped to the ADFG-CF Gene Conservation Lab in Anchorage at the end of the season.

SPAWNING LOCATION

Radio receivers (ATS Model R4500C) at each stationary tracking site will be visited and downloaded twice a month. Each record will contain the fields: year, Julian day, hour, minute, antenna, frequency, pulse code, signal strength, and duplicate counts, in ASCII text format. A laptop computer will be connected to the radio receiver with a serial cable and ATS software will be used to transfer the data file to the laptop. A logbook will be maintained at each station to note the date, staff, settings, and battery voltage for each visit. A checklist with radio receiver settings and the download steps will be at each site. Each downloaded file will be transferred to the Palmer local area network (LAN) and eventually appended into a single file.

Each record in the file will contain the site code, download date and time, radio frequency and pulse code, date and time of detection, antenna number, period, and signal strength (ATS unpublished). Each daily file will eventually be appended into a single file.

Aerial telemetry surveys will be conducted on the Susitna mainstem and Yentna rivers as well as the primary tributaries, to verify data collected at tracking stations and identify the locations of radio tagged fish during the likely spawning period. Spawning sites will be inferred by maximum upstream locations of radio tags. Automatically recorded data will include the date and time of decoding, and the frequency, pulse code, latitude and longitude, signal strength, and activity status of each decoded transmitter. Decisions to continue or terminate any given survey will be made real time as the number of tags found becomes apparent.

When the radio receiver operator hears a tag, the "HOLD" button will be pressed, and the receiver will lock on the frequency to identify the pulse code. When the "HOLD" button is pressed, the frequency, pulse code, mortality indicator, signal strength, and latitude-longitude will be automatically written to the internal memory of the receiver. The data in the internal memory will be downloaded to a Windows (Microsoft™) based personal computer after each survey. The flight path will be automatically recorded on a handheld GPS (Garmin™ Oregon) and then downloaded, using Garmin MapSource software, to a Windows (Microsoft™) based personal computer after each survey to document the drainages surveyed.

DATA REDUCTION

Paper data forms completed by SF crews recording fish wheel catch and effort (Appendicies B2, B5, and B8) will be entered into a Microsoft™ Excel database from the Mainstem, Yentna, Talachulitna, Lake Creek, Montana Creek, and the middle fork of the Chuiltna River field

camps. All raw data files downloaded from the electronic recording instruments (ATS radio receiver will be stored in a dedicated subdirectory on the Palmer ADF&G LAN in season as they become available. Only copies of the raw data files will be manipulated to construct a complete database that will then be used for analyses. Tag recovery data (radio frequencies) from camps will be entered by hand into a separate worksheet within the same file. CF data at Yentna will be obtained from Mark Willette daily and appended to the appropriate worksheet in the "2013 Susitna Chinook and Coho Database.xls".

A separate Microsoft™ Access database will be created to store and analyze all aerial survey and tracking station relocation records. Crystal Reports will be used to query this database.

The above databases will serve as the basis for all data analysis required to achieve the study objectives. After all data are edited and analyzed, a final copy of the databases (in comma delimited ASCII format) will be e-mailed, along with a data map, to Research and Technical Services (RTS) for archiving on the SF intranet site.

DATA ANALYSIS

ABUNDANCE

A two-sample mark-recapture model will be used to estimate the number of Chinook and coho salmon passing by the weir sites. The appropriate abundance estimator will depend on the results of the aforementioned tests. If stratification is not needed, Chapman's (1951) version of Petersen's abundance estimator for closed populations (see Seber 1982) will be used:

$$\hat{N} = \frac{(M+1)(\hat{C}+1)}{(R+1)} - 1 \tag{1}$$

where $\hat{N}$ = estimated number Chinook or coho salmon, M = the number of marked Chinook or coho salmon moving upstream of the mainstem or Yentna wheel tagging sites, $\hat{C}$ = the estimated number of Chinook ≥ 500mm MEF or the number of coho salmon inspected for marks at the 2nd event sampling fish wheels, and R = number of marked Chinook or coho salmon recaptured during 2nd event sampling. For Chinook salmon, we will estimate:

$$\hat{C} = \sum_{i=1}^{s} C_i \hat{p}_{500+,i} \tag{2}$$

where C_i = total number of Chinook salmon counted past 2nd event sampling site i (i = 1 to s where s = 2 for the Yentna experiment and s = 4 for the mainstem experiment), $\hat{p}_{500+,i}$ = estimated proportion of Chinook salmon at site i that were ≥ 500mm MEF. Length composition data collected at each 2nd event sampling site will be used to estimate:

$$\hat{p}_{500+,i} = n_{500+,i} / n_i \tag{3}$$

where n_i = total number of Chinook salmon sampled at site *i*, and $n_{500+,i}$ = those members of n_i that were ≥ 500mm MEF.

If temporal/geographic stratification is not required but stratification by size or sex is (see Appendix D1), the data will be fully stratified and estimates for each stratum will be generated using equations (1-3). These stratum estimates summed to estimate total abundance and variance.

An estimate of the variance for $\hat{N}$ will be obtained through bootstrapping (Efron and Tibshirani 1993), however deviating from the methods in Buckland and Garthwaite (1991) because 2nd event sampling is not random. The number of recaptures *R* will be modeled as a binomial proportion of the number of marks deployed *M* and a large number of bootstrap samples *R** will be generated. At each 2nd event sampling site, the proportions of Chinook salmon ≥ 500mm MEF will be modeled as a binomial processes as described in equation (3), a large number of bootstrap samples will be generated for each $\hat{p}_{500+,i}$ and bootstrap samples of $\hat{C}^*$ will be calculated using equation (2).

Subsequently, bootstrap sample $\hat{N}^*$ will be calculated using equation (1).

A minimum of 1,000,000 bootstrap samples (*B*) will be so drawn. The approximate variance will be calculated as:

$$\mathrm{var}(\hat{N}) = \frac{\sum_{b=1}^{B} (\hat{N}_b^* - \bar{\hat{N}}^*)^2}{B-1} \qquad (4)$$

where $\bar{\hat{N}}^*$ is the average of the $\hat{N}_b^*$.

If DIDSON sonar operations are required at any 2nd event sampling weirs, C_i as described in equation (2) above will be estimated for the portion of the sampling conducted with sonar. These procedures are described below. Uncertainty resulting from these estimation procedures will also be modeled using bootstrap procedures, integrated into the processes described above.

If geographic or temporal stratification is required, estimation of abundance will follow procedures described by Darroch (1961). Initial modeling will be conducted using the computer program SPAS (Arnason et al. 1996). If stratification by size is required, size stratification will be conducted first and methods to correct for geographic or temporal capture heterogeneity will be applied independently to each size stratum. The contingency tables described in Appendix D2 will be further analyzed to identify a) 1st event strata (individual or contiguous groupings of temporal/geographic categories) where probability of recapture during the second event is homogeneous within strata and different between strata; and b) 2nd event strata where marked: unmarked ratios are homogeneous within strata and different between strata. Temporal categories generally will consist of groupings of sample data collected by week. Stratification will also be guided by environmental conditions encountered during data collection (river stage height and rainfall) and by previous experience gained when conducting mark-recapture experiments on this system. If the initial stratification does not result in an admissible maximum-likelihood (ML) estimate of abundance, further stratification may be necessary before an admissible estimate can be calculated. Non-admissible estimates include failure of convergence of the ML algorithm in SPAS or convergence to estimators with estimated negative

capture probabilities or estimated negative abundance within stratum. Goals in this case are always that observations within the pooled stratum should be as homogeneous as possible with respect to capture, migration, and recapture (Arnason et al. 1996).

A Goodness of Fit (GOF) test (provided in SPAS) comparing the observed and predicted statistics will indicate the adequacy of a stratified model. Once a stratification is identified that results in an admissible estimate of abundance, GOF will be evaluated. Further stratification, according to the guidelines described above, may be necessary to produce a model and abundance estimate with a satisfactory GOF. In general, the model selected will be that which provides an admissible estimate of abundance where no stratification guidelines are violated, no significant evidence of lack of fit is detected, and the smallest number of strata parameters are estimated for the model. This model will usually yield the smallest ML estimate of variance for the abundance estimate.

If the Darroch (1961) procedure is used to estimate abundance and the number of first event (s) and second event (t) strata in the preferred model is not equal, further modeling will be conducted to identify an alternative preferred model with s equal to t. The reason for the alternative model is that an analytical solution may be calculated for the ML estimate of abundance using equations provided in Seber (1982) – no ML search algorithm is required. An analytical solution greatly simplifies the bootstrap modeling which will be used to estimated variance (described below). For $s < t$, typically the largest (most recaptures) marking strata in the preferred model can be divided into 2 or more smaller strata to increase s. For $s < t$, the 2nd event strata will be divided to provide a larger t. Several alternative models, constructed in the manner, may be explored using the SPAs software. For all but the most ill-behaved data sets, this process will commonly produce one or more alternative models where $s = t$ and the ML estimates of abundance and SE are nearly identical to, and not statistically discernable from, those estimates from the preferred model. The chosen alternative model will be that for which the parameter estimates most closely match the preferred model.

The SPAS software will provide an underestimate of the true variance, because the estimated components of $\hat{M}_{c\bullet}$ will be treated as scalars, rather than random variables. Using the preferred alternative model ($s = t$), bootstrap methodology (Efron and Tibshirani 1993) will be used to estimate variance and confidence intervals. The procedures describe in equations (2-4) above will generally be followed, except a more complex *epd* for fish in the population will be required. There will be (s)(t) capture histories for recaptured Chinook or coho salmon, s capture histories for salmon marked but never recaptured, t histories for coho salmon captured upstream in the in-river fisheries without marks, and one history for all salmon never caught.

Similar to what was described above for the Chapman estimator, a minimum of 1,000,000 bootstrap samples (B) will be drawn. For each bootstrap iteration, simultaneous randomized realization of each of these modeled distributions will be used to build the data necessary for a Darroch model. After drawing the distribution of recovered marks for each stratum, the total number of marks deployed will be adjusted down by the bootstrap estimates of handling and tag loss. The bootstrap realization of number of "unrecovered" marks for that stratum will also be adjusted downward accordingly (by subtraction). We will then calculate an estimate of $\hat{N}$ for each of the B bootstrap samples using the methods describe in section 11.1 of Seber (1982). Equation (5) will be used to estimate the variance of the abundance estimate. Application of the methods in section 11.1 of Seber (1982) will also simultaneously provide estimates of the number of fish in each of the s marking strata ($\hat{N}_s$) and each of the t 2nd event strata.

Sonar Passage Estimates of Chinook Salmon

The following procedures will be used to estimate the number of Chinook salmon ≥ 500mm MEF that migrate upstream past sonar sites. Estimates of fork length will be made from images of all fish exceeding approximately 400mm. True TL of each of these images will be predicted using the relationship based on tethered fish described in Miller et al. (2011, see fig. 25).

A model predicting MEF from TL will be developed based on measurements of Chinook salmon collected at each weir/sonar site using linear regression techniques (Neter et al. 1985). These models will be used to convert TL predictions from DIDSON images to MEF preditions.

For sonar images collected prior to 1 July 2013 and all images collected after that date prior to detection of salmon species other than Chinook, the passage of Chinook salmon ≥500mm will be estimated as the sum of all MEF predictions from DIDSON images that satisfy this criterion.

Variance will be calculated using bootstrap techniques (Efron and Tibshirani 1993). Bootstrap samples of the tethered fish data set described by Miller et al. (2011) will be used to generate bootstrap samples of slope and intercept for the relationship predicting TL from DIDSON images. Similarly, bootstrap samples of the appropriate data set of TL and MEF measurements will be used to generate bootstrap samples of the slope and intercept of the relationship predicting MEF from TL. These bootstrap samples of regression parameters will be used to generate bootstrap samples of predicted MEF from each DIDSON image, and bootstrap samples of the numbers of Chinook salmon ≥500mm will be generated by summing the number of predictions that meet this criterion for each bootstrap iteration. Variance will be calculated as described in equation (4), above.

For sonar images collected after other salmon species are detected at the sonar site, the procedures described above will be used to create MEF predictions from DIDSON images. Size composition data for Chinook salmon collected at the weir/sonar site will be examined using contingency table analysis to test the hypothesis that the proportions of Chinook salmon 500m-699mm to those ≥ 700mm MEF is independent of week or quartile when collected. The most recent portion of the data for which this relationship is relatively homogeneous will be used to estimate:

$$\hat{p}_{700+,i} = n_{700+,i} \big/ n_{500+,i} \tag{5}$$

where $n_{500+,i}$ = total number of Chinook salmon sampled at site *i* that were ≥ 500mm MEF, and $n_{700+,i}$ = those members of $n_{500+,i}$ that were ≥ 700mm MEF. The number of DIDSON images with predicted MEF

≥ 700mm will be tallied to create $\hat{C}_{700+,i}$, and we will estimate the number of Chinook salmon ≥ 500mm MEF using:

$$\hat{C}_{500+,i} = \hat{C}_{700+,i} \big/ \hat{p}_{700+,i} \tag{6}$$

To estimate variance, the data used for equation (5) will be modeled as a binomial process to create a bootstrap sample of $\hat{p}_{700+,i}$. This bootstrap sample will be used in concert with the

bootstrap procedures described above to create a bootstrap sample of the parameter $\hat{C}_{500+,i}$ and variance will be calculated using equation (4).

SPAWNING LOCATION

The fixed telemetry station at the lower Yentna and one mile upstream of the mainstem fish wheel site will be used as the gateway to the experiment for spawning location for all species. Fish that do not pass the gateway will be noted, and will not be used to characterize spawning distribution. Prior to determining spawning sites, all "lost" (including harvested fish) radio tagged fish will be identified and censored. Tag loss or fish mortality will be assumed for any tag that transmits an "inactive" code and for which upstream movement has ceased prior to reaching potential spawning areas. All tags that move downstream immediately after tagging and are not later detected moving upstream will be assumed to be handling mortalities, i.e., do not pass the gateway. Significant variations in fish mortality or tag loss over time and tagging site will be used to identify possible needs for changes in fish handling.

Following removal of "lost" tags, a final location will be determined for each tagged fish using the telemetry data. Radio tags deployed and relocated by date, species, and fish wheel (also gill net for Chinook salmon) will be tabulated. In most cases, the furthest upstream locations of a radio tagged fish will be assumed to be the actual spawning site or spawning drainage. However, in very few circumstances some judgment may be exercised to deviate from this guideline. For example, if following the extreme upstream location, a fish is later observed to spend more than 2 weeks (anticipated interval between aerial surveys) in a further downstream location or another tributary in the presence of other spawning fish, the latter site will be used rather than the extreme upstream location.

A map of the final locations of tagged fish by species and fish wheel will be constructed. Visually comparing final locations between fish wheels may be useful in detecting bank orientation, which must be considered when planning future experiments, especially for Chinook salmon.

SPAWNING DISTRIBUTION

For Chinook and coho salmon only, the diagnostic procedures described in Appendix D2 will be used to detect evidence of geographic or temporal variability in probability of capture during the marking event. The test results will guide stratification of groups of marked fish into S temporally and geographically contiguous strata, such that little or no evidence of variation in probability of capture is detectable within strata. A Darroch (1961) model, with $s = t$, will be used to estimate the total number of fish passing the marking sites within each marking stratum $\hat{N}_s$ (as described above). These estimates will not be mutually independent.

For each marking stratum, radio tagging data will be used to estimate spawning distribution

$$\hat{p}_{l,s} = n_{l,s} / n_s \tag{7}$$

Where $\hat{p}_{l,s} = n_{l,s} / n_s$ is the estimated proportion of salmon from stratum s spawning in location l, n_s is the number of fish radio-tagged in stratum s the travelled to a spawning location, and $n_{l,s}$ is the number of fish from n_s that travelled to location l.

The total number of salmon spawning in location l can be estimated

$$\hat{N}_l = \sum_{s=1}^{S} \hat{N}_s \hat{p}_{l,s} \tag{8}$$

and the proportion of salmon spawning in each location estimated

$$\hat{p}_l = \hat{N}_l \Big/ \sum_{s=1}^{S} \hat{N}_s \tag{9}$$

Variance for these parameters will be estimated using bootstrap procedures (Buckland and Garthwaite 1991). Variation in estimates of spawning distribution parameters within each of S stratum will be modeled using multinomial distributions and the observed data described in equation (7).

A minimum of 1,000,000 bootstrap samples (B) will be drawn for spawning distribution for each marking stratum. Equations (8) and (9) will then be used to provide a bootstrap estimate of spawning distribution proportions. Variance for each of these parameters will then be estimated using methods analogous to equation (4).

GENETICS SAMPLES

Tissue samples will be collected by SF personnel and transferred to CF at the end of the field season. All genetics data will be maintained by the CF Gene Conservation Lab in Anchorage.

SCHEDULE AND DELIVERABLES

1. Deploy fixed radio tracking stations 21 May-10 June, 2013
2. Download fixed radio tracking stations approximately every 1-3 weeks, 1 June-5 September, 2013
3. Fish wheel operations and gill netting begin at Mainstem Susitna and Yentna rivers 22 May, 2013
4. Radio telemetry aerial surveys approximately every 2 weeks, 16 June – 5 October, 2013
5. Complete fish wheel and gill net sampling at Mainstem and Yentna sites 30 June, 2013
6. Complete weir sampling at Lake Creek, Talachulitna River, and middle fork Chulitna River approximately 15 July, 2013
7. Complete weir sampling at Deshka River and Montana Creek approximately 5 September, 2013
8. Data reduction and analysis 15 September - 31 December, 2013
9. Final 2013 Fishery Data Series Report 30 November, 2013

Genetics results will be reported separately, to be determined.

RESPONSIBILITIES

Pete Cleary (Fishery Biologist II):

Directly supervise Mainstem Susitna operations and Talachulitna, Lake Creek, Montana Creek weir/sonar. Oversee all SF fish wheel portions of project: planning, budgeting, hiring and training field staff, data collection, editing and analysis, supervision, and purchasing. Coordinate with John Campbell on radio tag deployment. Lead author on operational plan and report.

John Campbell (Fishery Biologist II):

Lead all radio telemetry and tracking portions of project: planning, budgeting, data collection, data analysis, purchasing, reporting, crew training, radio tracking station setup and downloads, and aerial surveys. Assist with hiring and training and writing the operational plan. Coauthor on report.

Dan Reed (Biometrician III):

Advise all portions of the biometrics: planning, sample sizes, statistical methods, and data analysis.

Chris Habicht (Geneticist):

Advice on portions of the genetics: planning, sample sizes, statistical methods, data analysis, and reporting.

Bob Decino (Fishery Biologist II):

Oversee CF wheel 1 and CF crew at Flathorn: planning, budgeting, hiring and training field staff, supervision, data collection, and purchasing. Provide sampling data from wheel 1 at Flathorn.

Mark Willette (Fishery Biologist III):

Oversee all Yentna portions of project: planning, budgeting, hiring and training field staff, supervision, data collection, and purchasing. Provide sampling data from Yentna.

Richard Yanusz (Fishery Biologist III):

Review all aspects of project: planning, budget, data collection, data analysis, and reporting.

Steve Dotomain (Fishery Biologist I):

Assist with all aspects of Flathorn and mainstem Susitna sites: planning, budgeting, hiring and training field staff, data collection, data analysis, supervision, and purchasing. Assist with radio telemetry data collection as needed.

Nick Logelin (Fishery Biologist I):

Conduct logistics for weir field camps, assist with field work to collect radio telemetry data.

Taylor Hendricks (Fish and Wildlife Technician III):

Conduct field camp supervision and field sampling at the Mainstem camp according to operational plan and verbal instructions. Install, operate, maintain, and break down a remote field camp and fish wheels. Operate scientific instruments, computers, river boats, and hand and power tools

Technicians (Fish and Wildlife Technician II or III, College Intern II):

Conduct field sampling at Flathorn and mainstem Susitna sites according to operational plan and verbal instructions. Install, operate, maintain, and break down a remote field camp and fish wheels. Operate scientific instruments, computers, river boats, and hand and power tools.

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TABLES AND FIGURES

Table 1.–Crew schedule for fishing drift gill nets and the radio tag deployment schedule at the mainstem Susitna site.

Drift net crew schedule - Susitna/Yenta Chinook - 2013

	Morning		Afternoon			
Date	Start	Stop	Start	Stop	Daily radios	Tags/Shift
22-May	9:00	12:45	17:00	20:45	1	morning
23-May	8:00	11:45	16:00	19:45	1	afternoon
24-May	7:00	10:45	15:00	18:45	1	morning
25-May	6:00	9:45	14:00	17:45	1	afternoon
26-May	7:00	10:45	15:00	18:45	1	morning
27-May	8:00	11:45	16:00	19:45	1	afternoon
28-May	9:00	12:45	17:00	20:45	2	both
29-May	10:00	13:45	18:00	21:45	2	both
30-May	11:00	14:45	19:00	22:45	3	morning =2
31-May	12:00	15:45	20:00	23:45	3	afternoon =2
1-Jun	11:00	14:45	19:00	22:45	4	both
2-Jun	10:00	13:45	18:00	21:45	4	both
3-Jun	9:00	12:45	17:00	20:45	5	morning = 3
4-Jun	8:00	11:45	16:00	19:45	5	morning =2
5-Jun	7:00	10:45	15:00	18:45	5	morning = 3
6-Jun	6:00	9:45	14:00	17:45	5	morning =2
7-Jun	7:00	10:45	15:00	18:45	5	morning = 3
8-Jun	8:00	11:45	16:00	19:45	5	morning = 2
9-Jun	9:00	12:45	17:00	20:45	5	morning = 3
10-Jun	10:00	13:45	18:00	21:45	5	morning = 2
11-Jun	11:00	14:45	19:00	22:45	4	both
12-Jun	12:00	15:45	20:00	23:45	4	both
13-Jun	11:00	14:45	19:00	22:45	4	both
14-Jun	10:00	13:45	18:00	21:45	4	both
15-Jun	9:00	12:45	17:00	20:45	4	both
16-Jun	8:00	11:45	16:00	19:45	3	morning = 1
17-Jun	7:00	10:45	15:00	18:45	3	morning = 2
18-Jun	6:00	9:45	14:00	17:45	2	both
19-Jun	7:00	10:45	15:00	18:45	2	both
20-Jun	8:00	11:45	16:00	19:45	1	afternoon
21-Jun	9:00	12:45	17:00	20:45	0	
22-Jun	10:00	13:45	18:00	21:45	1	morning
23-Jun	11:00	14:45	19:00	22:45	0	
24-Jun	12:00	15:45	20:00	23:45	1	afternoon
25-Jun	11:00	14:45	19:00	22:45	0	
26-Jun	10:00	13:45	18:00	21:45	1	morning
27-Jun	9:00	12:45	17:00	20:45	0	
28-Jun	8:00	11:45	16:00	19:45	1	afternoon
29-Jun	7:00	10:45	15:00	18:45	0	
30-Jun	6:00	9:45	14:00	17:45	1	morning

Table 2.–The 2013 Chinook salmon radio tagging schedule by fish wheel (FW) and gill net.

Date	FW1	FW2	Total FW	Gillnets	All Tags
22-May-13	2	1	3	1	4
23-May-13	1	2	3	1	4
24-May-13	2	1	3	1	4
25-May-13	1	2	3	1	4
26-May-13	3	3	6	1	7
27-May-13	5	4	9	1	10
28-May-13	6	6	12	2	14
29-May-13	7	8	15	2	17
30-May-13	9	9	18	3	21
31-May-13	11	10	21	3	24
1-Jun-13	12	12	24	4	28
2-Jun-13	13	14	27	4	31
3-Jun-13	15	15	30	5	35
4-Jun-13	15	15	30	5	35
5-Jun-13	15	15	30	5	35
6-Jun-13	15	15	30	5	35
7-Jun-13	15	15	30	5	35
8-Jun-13	15	15	30	5	35
9-Jun-13	15	15	30	5	35
10-Jun-13	15	15	30	5	35
11-Jun-13	14	13	27	4	31
12-Jun-13	13	14	27	4	31
13-Jun-13	14	13	27	4	31
14-Jun-13	12	12	24	4	28
15-Jun-13	10	11	21	4	25
16-Jun-13	9	9	18	3	21
17-Jun-13	8	7	15	3	18
18-Jun-13	6	6	12	2	14
19-Jun-13	4	5	9	2	11
20-Jun-13	3	3	6	1	7
21-Jun-13	2	1	3	0	3
22-Jun-13	1	2	3	1	4
23-Jun-13	2	1	3	0	3
24-Jun-13	1	2	3	1	4
25-Jun-13	2	1	3	0	3
26-Jun-13	1	2	3	1	4
27-Jun-13	2	1	3	0	3
28-Jun-13	1	2	3	1	4
29-Jun-13	2	1	3	0	3
30-Jun-13	1	2	3	1	4
Total Tags	300	300	600	100	700

Table 3.–The 2013 coho and pink salmon radio tagging schedule by fish wheel (FW).

	Coho			Pink		
Date	FW1	FW2	Total	FW1	FW2	Total
6-Jul	0	0	0	0	0	0
7-Jul	3	3	6	0	0	0
8-Jul	3	3	6	0	0	0
9-Jul	3	3	6	0	0	0
10-Jul	6	6	12	0	0	0
11-Jul	3	3	6	0	0	0
12-Jul	6	6	12	0	0	0
13-Jul	6	6	12	0	0	0
14-Jul	6	6	12	1	1	2
15-Jul	12	12	24	0	0	0
16-Jul	12	12	24	1	1	2
17-Jul	9	9	18	1	1	2
18-Jul	9	9	18	3	3	6
19-Jul	6	6	12	3	3	6
20-Jul	6	6	12	4	4	8
21-Jul	12	12	24	4	4	8
22-Jul	12	12	24	4	4	8
23-Jul	12	12	24	6	6	12
24-Jul	9	9	18	8	8	16
25-Jul	15	15	30	9	9	18
26-Jul	12	12	24	7	7	14
27-Jul	9	9	18	6	6	12
28-Jul	9	9	18	6	6	12
29-Jul	12	12	24	6	6	12
30-Jul	9	9	18	5	5	10
31-Jul	9	9	18	4	4	8
1-Aug	9	9	18	4	4	8
2-Aug	9	9	18	4	4	8
3-Aug	9	9	18	2	2	4
4-Aug	9	9	18	1	1	2
5-Aug	9	9	18	1	1	2
6-Aug	9	9	18	1	1	2
7-Aug	6	6	12	1	1	2
8-Aug	6	6	12	1	1	2
9-Aug	6	6	12	1	1	2
10-Aug	3	3	6	1	1	2
11-Aug	6	6	12	1	1	2
12-Aug	3	3	6	1	1	2
13-Aug	0	0	0	1	1	2
14-Aug	0	0	0	1	1	2
15-Aug	3	3	6	0	0	0
16-Aug	0	0	0	1	1	2
17-Aug	0	0	0	0	0	0
18-Aug	0	0	0	0	0	0
19-Aug	0	0	0	0	0	0
20-Aug	3	3	6	0	0	0
21-Aug	0	0	0	0	0	0
22-Aug	0	0	0	0	0	0
23-Aug	0	0	0	0	0	0
24-Aug	0	0	0	0	0	0
25-Aug	0	0	0	0	0	0
26-Aug	0	0	0	0	0	0
27-Aug	0	0	0	0	0	0
28-Aug	0	0	0	0	0	0
29-Aug	0	0	0	0	0	0
30-Aug	0	0	0	0	0	0
31-Aug	0	0	0	0	0	0
1-Sep	0	0	0	0	0	0
Totals	300	300	600	100	100	200

Table 4.–Fixed radio tracking station locations throughout the mainstem Susitna and Yentna River drainages, 2012.

Line	Drainage	Site Name	Latitude (degrees)	Longitude (degrees)
1	Yentna	Lower Yentna	61.663590	150.625670
2		Skwentna	61.872677	151.352585
3		Upper Yentna	62.193820	151.587830
1	Susitna	Susitna Station	61.544250	150.515350
2		Deshka mouth	61.691270	150.306320
3		Sunshine	62.173000	150.174280
4		Middle Susitna	62.455387	150.126907
5		Talkeetna	62.347538	150.014633
6		Chulitna	62.488510	150.259920
datum is WGS84				

Table 5.–Sampling rate for scales from Chinook salmon at weirs, based upon the doubling the lower aerial escapement goal.

	Lake Creek	Talachulitna River	Montana Creek	Chulitna River
Lower Escapement Goal	2,500	2,200	1,100	1,800
Upper Escapement Goal	7,100	5,000	3,100	5,100
Double lower range	5,000	4,400	2,200	3,600
Sample goal	350	350	350	350
Ratio	14.29	12.57	6.29	10.29
Sampling rate (every nth fish)	15	15	7	10

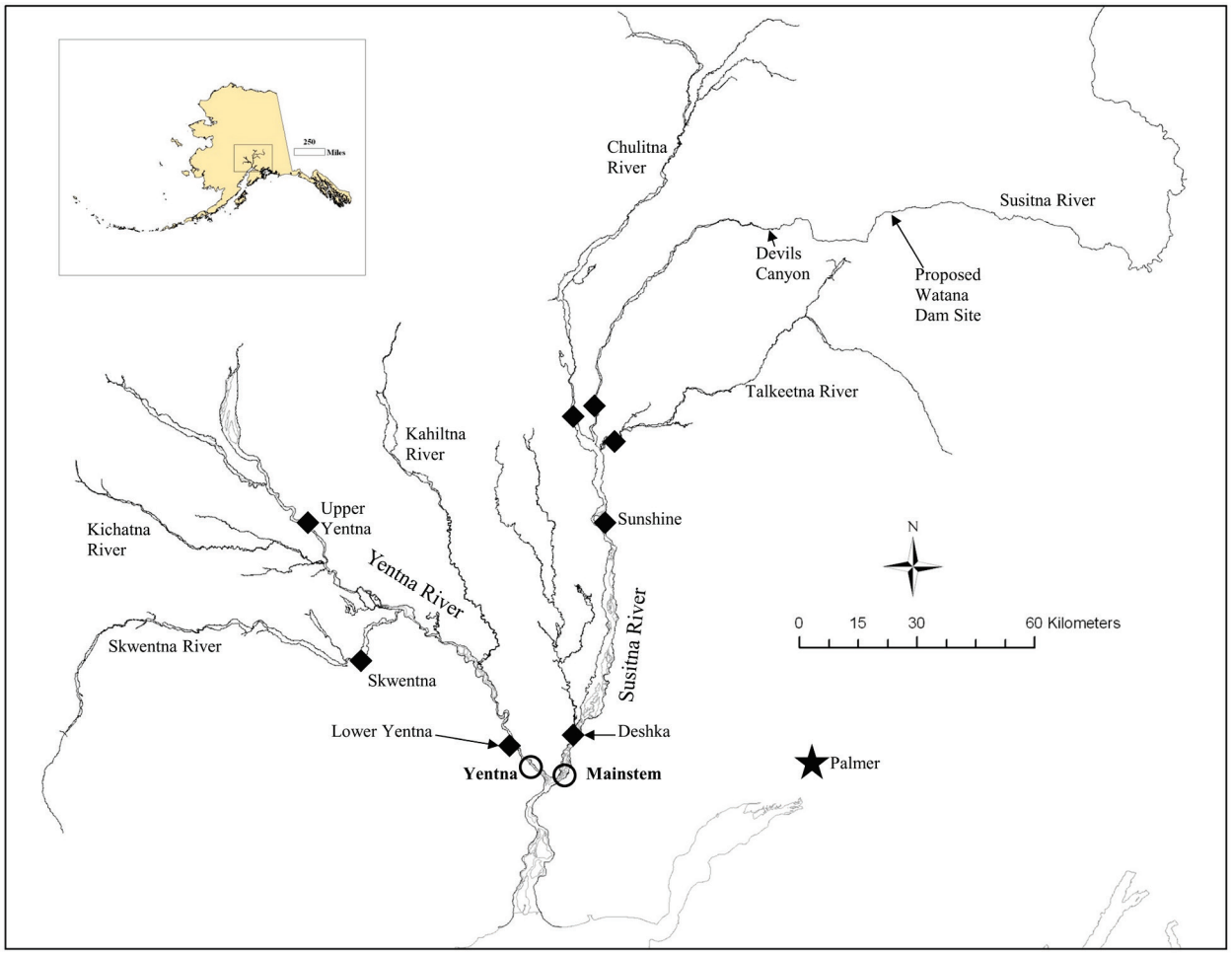

Figure 1.–Capture sites (open circles) for Chinook coho, and pink salmon, fixed radio tracking stations (diamonds), and the proposed Watana dam site in the Susitna River, Alaska. Mainstem will be the capture site for Chinook, coho, and pink salmon while the Yentna site will deploy tags in Chinook salmon only.

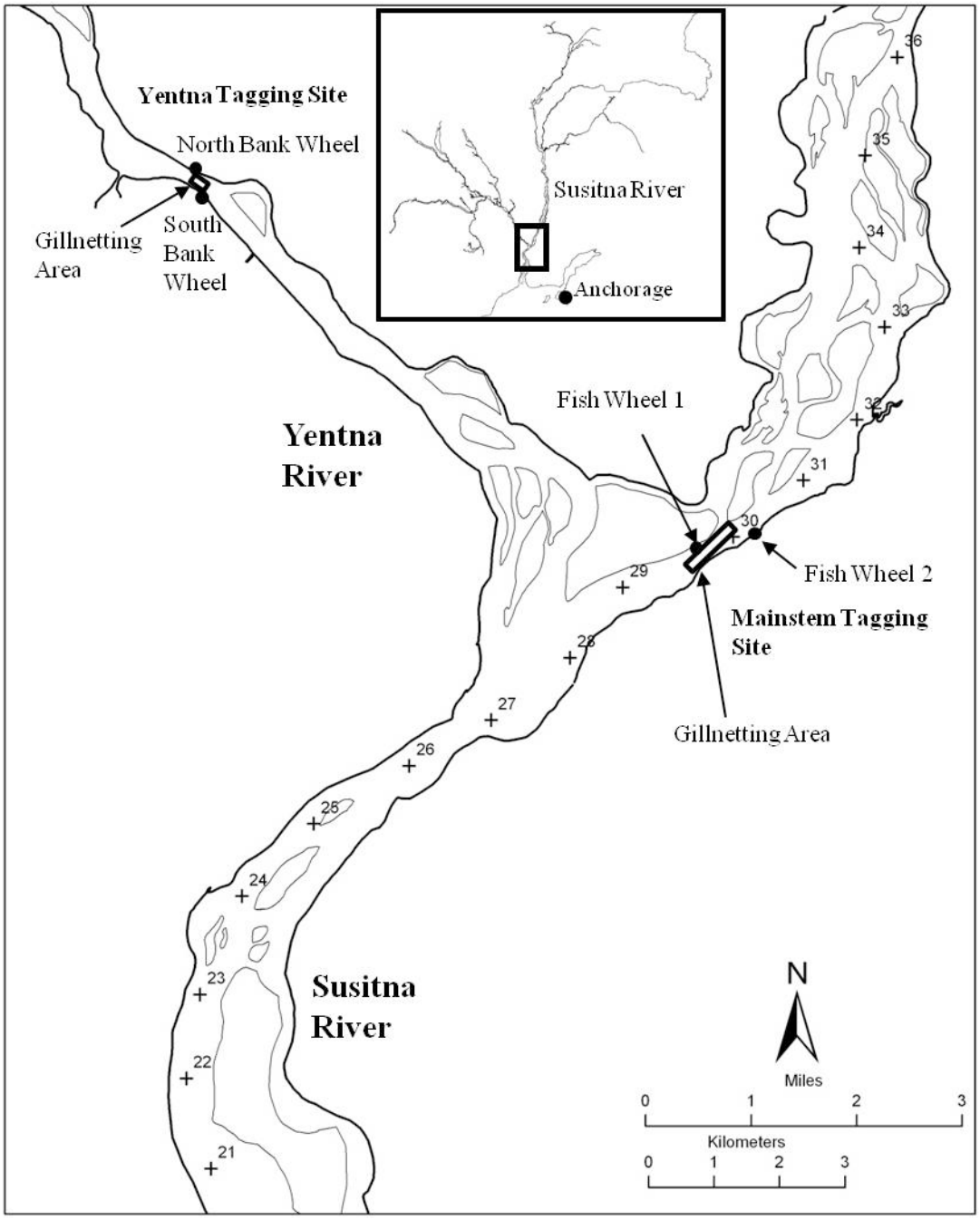

Figure 2.–Tagging sites and river miles, 2013.

APPENDIX A

Appendix A1.-2013 shift schedules.

		Shift 1		Shift 2		Crew Schedule	
Date	Day	Start	Stop	Start	Stop	**Crew 1**	**Crew 2**
5/22	Wed	0500	1300	1400	2200	Shift 1	Shift 2
5/23	Thu	0500	1300	1400	2200	Shift 1	Shift 2
5/24	Fri	0500	1300	1400	2200	Shift 1	Shift 2
5/25	Sat	0500	1300	1400	2200	Shift 1	Shift 2
5/26	Sun	0500	1300	1400	2200	Shift 1	Shift 2
5/27	Mon	0500	1300	1400	2200	Shift 1	Shift 2
5/28	Tue	0500	1300	1400	2200	Shift 1	Shift 2
5/29	Wed	0500	1300	1400	2200	Shift 1	Shift 2
5/30	Thu	0500	1300	1400	2200	Shift 1	Shift 2
5/31	Fri	0500	1300	1400	2200	Shift 1	Shift 2
6/1	Sat	0500	1300	1400	2200	Shift 1	Shift 2
6/2	Sun	0500	1300	1400	2200	Shift 1	Shift 2
6/3	Mon	0500	1300	1400	2200	Shift 1	Shift 2
6/4	Tue	0500	1300	1400	2200	Shift 1	Shift 2
6/5	Wed	0500	1300	1400	2200	Shift 1	Shift 2
6/6	Thu	0500	1300	1400	2200	Shift 1	Shift 2
6/7	Fri	0500	1300	1400	2200	Shift 1	Shift 2
6/8	Sat	0500	1300	1400	2200	Shift 2	Shift 1
6/9	Sun	0500	1300	1400	2200	Shift 2	Shift 1
6/10	Mon	0500	1300	1400	2200	Shift 2	Shift 1
6/11	Tue	0500	1300	1400	2200	Shift 2	Shift 1
6/12	Wed	0500	1300	1400	2200	Shift 2	Shift 1
6/13	Thu	0500	1300	1400	2200	Shift 2	Shift 1
6/14	Fri	0500	1300	1400	2200	Shift 2	Shift 1
6/15	Sat	0500	1300	1400	2200	Shift 2	Shift 1
6/16	Sun	0500	1300	1400	2200	Shift 2	Shift 1
6/17	Mon	0500	1300	1400	2200	Shift 2	Shift 1
6/18	Tue	0500	1300	1400	2200	Shift 2	Shift 1
6/19	Wed	0500	1300	1400	2200	Shift 2	Shift 1
6/20	Thu	0500	1300	1400	2200	Shift 2	Shift 1
6/21	Fri	0500	1300	1400	2200	Shift 2	Shift 1
6/22	Sat	0500	1300	1400	2200	Shift 2	Shift 1
6/23	Sun	0500	1300	1400	2200	Shift 2	Shift 1
6/24	Mon	0500	1300	1400	2200	Shift 2	Shift 1
6/25	Tue	0500	1300	1400	2200	Shift 2	Shift 1
6/26	Wed	0500	1300	1400	2200	Shift 2	Shift 1
6/27	Thu	0500	1300	1400	2200	Shift 2	Shift 1

continued

Appendix A1.-Page 2 of 3.

		Shift 1		Shift 2		Crew Schedule	
Date	Day	Start	Stop	Start	Stop	**Crew 1**	**Crew 2**
6/28	Fri	0500	1300	1400	2200	Shift 1	Shift 2
6/29	Sat	0500	1300	1400	2200	Shift 1	Shift 2
6/30	Sun	0500	1300	1400	2200	Shift 1	Shift 2
7/1	Mon	0500	1300	1400	2200	Shift 1	Shift 2
7/2	Tue	0500	1300	1400	2200	Shift 1	Shift 2
7/3	Wed	0500	1300	1400	2200	Shift 1	Shift 2
7/4	Thu	0500	1300	1400	2200	Shift 1	Shift 2
7/5	Fri	0500	1300	1400	2200	Shift 1	Shift 2
7/6	Sat	0500	1300	1400	2200	Shift 1	Shift 2
7/7	Sun	0500	1300	1400	2200	Shift 1	Shift 2
7/8	Mon	0500	1300	1400	2200	Shift 1	Shift 2
7/9	Tue	0500	1300	1400	2200	Shift 1	Shift 2
7/10	Wed	0500	1300	1400	2200	Shift 1	Shift 2
7/11	Thu	0500	1300	1400	2200	Shift 1	Shift 2
7/12	Fri	0500	1300	1400	2200	Shift 1	Shift 2
7/13	Sat	0500	1300	1400	2200	Shift 1	Shift 2
7/14	Sun	0500	1300	1400	2200	Shift 1	Shift 2
7/15	Mon	0500	1300	1400	2200	Shift 1	Shift 2
7/16	Tue	0500	1300	1400	2200	Shift 1	Shift 2
7/17	Wed	0500	1300	1400	2200	Shift 1	Shift 2
7/18	Thu	0500	1300	1400	2200	Shift 1	Shift 2
7/19	Fri	0500	1300	1400	2200	Shift 1	Shift 2
7/20	Sat	0500	1300	1400	2200	Shift 1	Shift 2
7/21	Sun	0500	1300	1400	2200	Shift 1	Shift 2
7/22	Mon	0500	1300	1400	2200	Shift 1	Shift 2
7/23	Tue	0500	1300	1400	2200	Shift 1	Shift 2
7/24	Wed	0500	1300	1400	2200	Shift 1	Shift 2
7/25	Thu	0500	1300	1400	2200	Shift 1	Shift 2
7/26	Fri	0500	1300	1400	2200	Shift 1	Shift 2
7/27	Sat	0500	1300	1400	2200	Shift 1	Shift 2
7/28	Sun	0500	1300	1400	2200	Shift 1	Shift 2
7/29	Mon	0500	1300	1400	2200	Shift 1	Shift 2
7/30	Tue	0500	1300	1400	2200	Shift 1	Shift 2
7/31	Wed	0500	1300	1400	2200	Shift 1	Shift 2
8/1	Thu	0500	1300	1400	2200	Shift 1	Shift 2

continued

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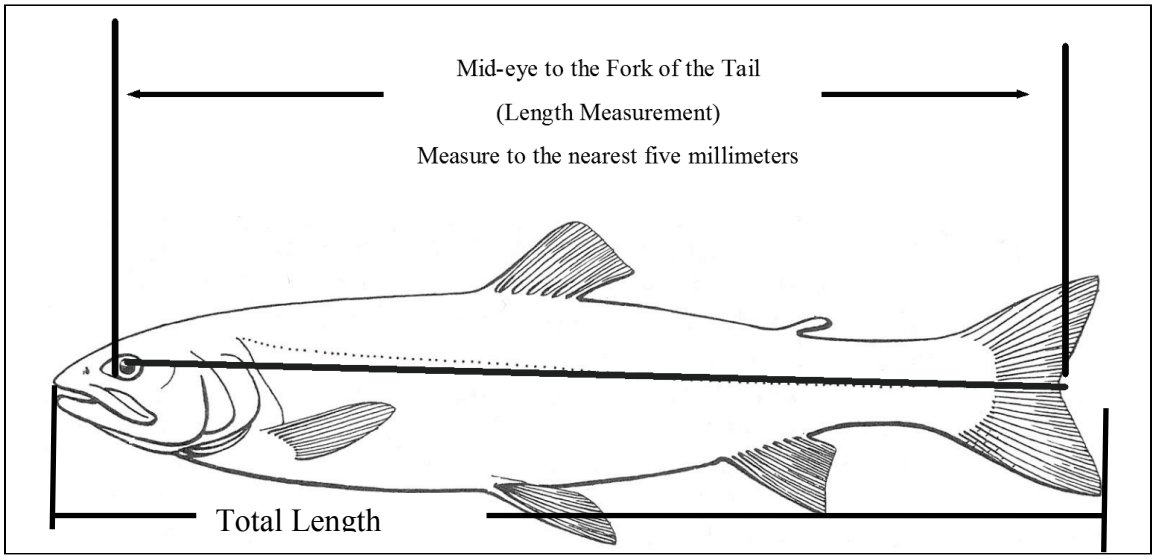
		Shift 1		Shift 2		Crew Schedule	
Date	Day	Start	Stop	Start	Stop	**Crew 1**	**Crew 2**
8/2	Fri	0500	1300	1400	2200	Shift 2	Shift 1
8/6	Sat	0500	1300	1400	2200	Shift 2	Shift 1
8/7	Sun	0500	1300	1400	2200	Shift 2	Shift 1
8/8	Mon	0500	1300	1400	2200	Shift 2	Shift 1
8/9	Tue	0500	1300	1400	2200	Shift 2	Shift 1
8/10	Wed	0500	1300	1400	2200	Shift 2	Shift 1
8/11	Thu	0500	1300	1400	2200	Shift 2	Shift 1
8/12	Fri	0500	1300	1400	2200	Shift 2	Shift 1
8/13	Sat	0500	1300	1400	2200	Shift 2	Shift 1
8/14	Sun	0500	1300	1400	2200	Shift 2	Shift 1
8/15	Mon	0500	1300	1400	2200	Shift 2	Shift 1
8/16	Tue	0500	1300	1400	2200	Shift 2	Shift 1
8/17	Wed	0500	1300	1400	2200	Shift 2	Shift 1
8/18	Thu	0500	1300	1400	2200	Shift 2	Shift 1
8/19	Fri	0500	1300	1400	2200	Shift 2	Shift 1
8/20	Sat	0500	1300	1400	2200	Shift 2	Shift 1
8/21	Sun	0500	1300	1400	2200	Shift 2	Shift 1
8/22	Mon	0500	1300	1400	2200	Shift 2	Shift 1
8/23	Tue	0500	1300	1400	2200	Shift 2	Shift 1
8/24	Wed	0500	1300	1400	2200	Shift 2	Shift 1
8/25	Thu	0500	1300	1400	2200	Shift 2	Shift 1
8/26	Fri	0500	1300	1400	2200	Shift 2	Shift 1
8/27	Sat	0500	1300	1400	2200	Shift 2	Shift 1
8/28	Sun	0500	1300	1400	2200	Shift 2	Shift 1
8/29	Mon	0500	1300	1400	2200	Shift 2	Shift 1
8/30	Tue	0500	1300	1400	2200	Shift 2	Shift 1
8/31	Wed	0500	1300	1400	2200	Shift 2	Shift 1
9/1	Thu	0500	1300	1400	2200	Shift 2	Shift 1
9/2	Fri	0500	1300	1400	2200	Shift 2	Shift 1
9/3	Sat	0500	1300	1400	2200	Shift 2	Shift 1
9/4	Sun	0500	1300	1400	2200	Shift 2	Shift 1
9/5	Mon	0500	1300	1400	2200	Shift 2	Shift 1

Appendix A2.–Measuring salmon for length (mid-eye to fork of tail).



Appendix A3.–Genetic tissue sample collection procedures.

Non-lethal Sampling of Finfish Tissue for DNA Analysis

ADF&G Gene Conservation Lab, Anchorage

I. General Information

We use axillary process samples from individual fish to determine the genetic characteristics and profile of a particular run or stock of fish. This is a non-lethal method of collecting tissue samples from adult fish for genetic analysis. The most important thing to remember in collecting samples is that **only quality tissue samples give quality results**. If sampling from carcasses: tissues need to be as "fresh" and as cold as possible and recently moribund, do not sample from fungal fins.

Sample preservative: Ethanol (ETOH) preserves tissues for later DNA extraction without having to store frozen tissues. Avoid extended contact with skin.

II. Sample procedure:

1. Tissue type: Axillary process, clip axillary process from each fish (Figure A3a).
2. Data to record: Record each vial number to paired data information.
3. Prior to sampling, fill the tubes half way with ETOH from the squirt bottle. Fill only the tubes that you will use for a particular sampling period.
4. To avoid any excess water or fish slime in the vial, wipe the axillary process dry prior to sampling. Using the dog toe nail clipper or scissors, clip off axillary process (**1/2 -1" max**) to fit into the cryovial.
5. Place axillary process into ETOH. The tissue/ethanol ratio should be **slightly less than 1:3** to thoroughly soak the tissue in the buffer.
6. Top up tubes with ETOH and screw cap on securely. Invert tube twice to mix ETOH and tissue. Periodically, wipe the dog toe nail clippers or scissor blade so not to cross contaminate samples.
7. Discard remaining ethanol from the 500ml bottle before returning samples. **Tissue samples must remain in 2ml ethanol** after sampling. HAZ-MAT paperwork will be required for return shipment. Store vials containing tissues at cool or room temperature, away from heat in the white sample boxes provided. In the field: keep samples out of direct sun, rain and store capped vials in a dry, cool location. Freezing not required.

III. Supplies included with sampling kit:

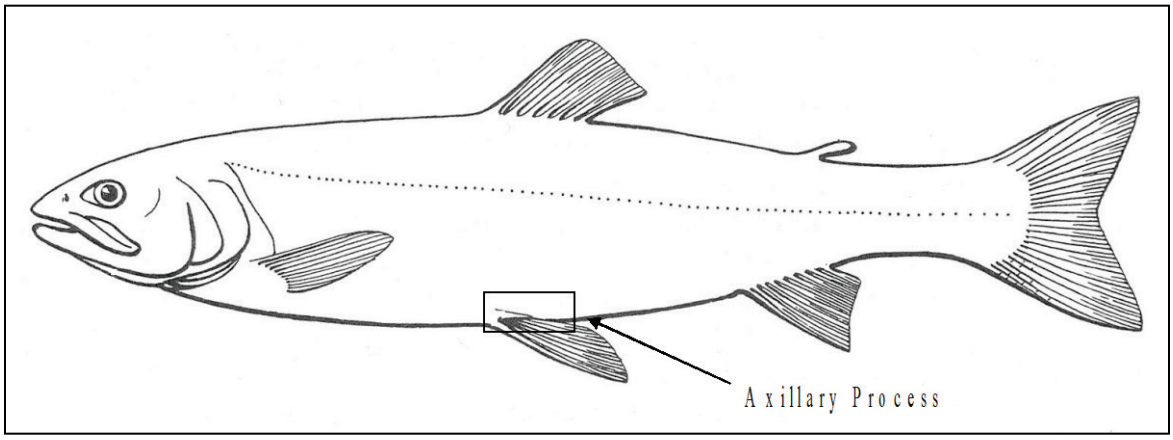
1. (1) – Dog toe nail clipper - used for cutting the axillary process
2. (1) – Scissors can be used to cut a portion axillary process – if clippers don't work for your crew
3. Cryovial- a small (2ml) plastic vial, pre-labeled.
4. Caps – with or without gasket to prevent evaporation of ETOH.
5. Cryovial rack- white plastic rack with holes for holding cryovials while sampling
6. Ethanol (ETOH) – in (2) 500 ml plus (1) – 125 ml Nalgen bottle
7. Squirt bottle – to fill or "top off" each cryovial with ETOH
8. Paper towels – use to blot any excess water or fish slime off axillary process
9. Printout of sampling instructions
10. (3) – three pair of lab gloves (size large)
11. Laminated "return address" label

IV. Shipping: HAZMAT paperwork is required for return shipment of these samples and is included in the kit.

Ship samples to: ADF&G – Genetics
333 Raspberry Road

Lab staff: 1-907-267-2247
Judy Berger: 1-907-267-2175

Figure A1.-Location of axillary process.



APPENDIX B

Appendix B1.–Daily radio tag summary form for 2013.

SUSITNA CHINOOK/COHO FISHWHEEL CATCH SUMMARY - 2013

Species* : K=KING, CO=COHO

Date: Site: Wheel: **1 2** Samplers: Shift **1 2** Page of

#	Species*	MEF Length	Total Length	Release Time	Inj.	Esc.	#	Species*	MEF Length	Total Length	Release Time	Inj.	Esc.	#	Species*	MEF Length	Total Length	Release Time	Inj.	Esc.
1							32							64						
2							33							65						
3							34							66						
4							35							67						
5							36							68						
6							37							69						
7							38							70						
8							39							71						
9							40							72						
10							41							73						
11							42							74						
12							43							75						
13							44							76						
14							45							77						
15							46							78						
16							47							79						
17							48							80						
18							49							81						
19							50							82						
20							51							83						
21							52							84						
22							53							85						
23							54							86						
24							55							87						
25							56							88						
26							57							89						
27							58							90						

Notes:

Appendix B2.–Catch and Effort data form for Mainstem, 2013.

SUSITNA CHINOOK & COHO FISHWHEEL CATCH AND EFFORT - 2013

Date: Shift: **1** **2** Samplers: Fishwheel: **1** **2** RPM Start: RPM End:

Spin Time:	start	stop	start	stop	start	stop	start	stop	stop	start	stop	stop	stop	start	stop	Total Min.

Sample Session		**KING**		**Coho**		**Pink**		**Other Species**			**Notes**
Start	Stop	**Total**	**Tags**	**Total**	**Tags**	**Total**	**Tags**	Sockey	Chum	other*	
Totals											

* OTHER SPECIES CODES: NP=Northern Pike, B=Burbot, AG=Arctic Grayling, RT=Rainbow Trout, BC=Bering Cisco, HWF=Humpback Whitefish, RWF=Round Whitefish, LNS=Longnose Sucker, AC=Arctic Char

Radio Tagging Tracking

Species	Frequency	Code	Vial	MEF Length	Release Time	Process Min	Total Length	Notes

Radio Tagging Tracking

Species	Frequency	Code	Vial	MEF Length	Release Time	Process Min	Total Length	Notes

Appendix B3.–Catch and Effort data form for Mainstem gill net, 2013.

SUSITNA CHINOOK GILL NET CATCH AND EFFORT/RADIO FORM - 2013

GILLNET CATCH AND EFFORT Date: Site: Samplers: Shift: **1 2**

Gillnet					Chinook		Other Species				Comments
Set	**Mesh**	**Site**	**Start**	**End**	**Radios**	**Total**	**SS**	**CS**	**PS**	**O****	
				Totals							

** OTHER SPECIES CODES: NP=Northern Pike, B=Burbot, AG=Arctic Grayling, RT=Rainbow Trout, BC=Bering Cisco, HWF=Humpback Whitefish, RWF=Round Whitefish, LNS=Longnose Sucker, AC=Arctic Char/Dolly

Appendix B3. Page 2 of 2.

Catch and Effort data form for Mainstem gill net, 2013.

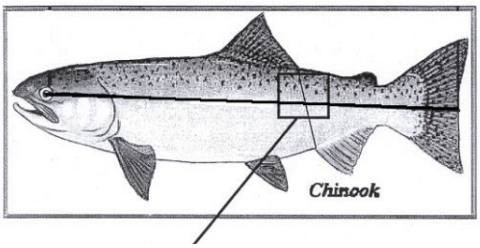
Cont'd

RADIO TAGGING SUMMARY - GILL NET CATCH *Enter the letter that corresponds to the catch types G/B/W= Gilled/Body/Wrapped

Radio		Age, Sex, Length, Genetics					Catch	Released	Comments
Freq.	Pulse	Vial	MEF Length	Total Length	Process Time	Release Time	Type G/B/W*	Inj. Escape (I/E)	

APPENDIX C

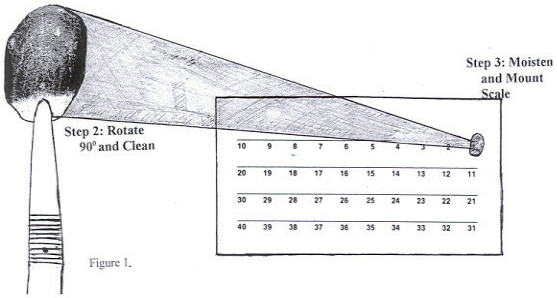
Appendix C1.–Scale collection procedure.



Preferred scale is located on the two rows above the lateral line along a diagonal line from back (posterior) of the dorsal fin to the front **(anterior**) of the anal fin.

Pluck the "preferred scale" from the fish using forceps.

Pliers may be necessary to remove scales if the fish has been in freshwater for an extended period, such as late season sampling.

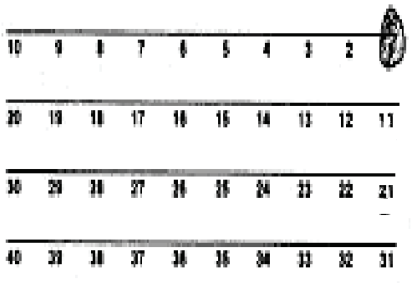


Remove all slime, grit and skin from scale by moistening and rubbing between thumb and forefinger. Moisten theclean scale and mount it on the gummed card directlyon top of the number "1".

A good scale has a well rounded shape.

Hold scale up to light and examine for overall size, shape, regeneration, deformities, etc.

Continuing, mount the 2nd and 3rd scales from fish #1 the numerals "11" and "21", filling in each column. Only 10 fish will fit on a card, one fish per column.



APPENDIX D

Appendix D1.–Detection of size and/or sex selective sampling during a two-sample mark recapture experiment and its effects on estimation of population size and population composition.

Size selective sampling: The Kolmogorov-Smirnov two sample test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first and/or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test that compares M and C is then conducted and used to evaluate the results of the first two tests when sample sizes are small. Guidelines for small sample sizes are <30 for R and <100 for M or C.

Sex selective sampling: Contingency table analysis (Chi^2-test) is generally used to detect significant evidence that sex selective sampling occurred during the first and/or second sampling events. The counts of observed males to females are compared between M&R, C&R, and M&C using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. If the proportions by gender are estimated for a sample (usually C), rather an observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are then compared between samples using a two sample test (e.g. Student's t-test).

M vs. R	**C vs. R**	**M vs. C**
Case I:		
Fail to reject H_o	Fail to reject H_o	Fail to reject H_o
There is no size/sex selectivity detected during either sampling event.		
Case II:		
Reject H_o	Fail to reject H_o	Reject H_o
There is no size/sex selectivity detected during the first event but there is during the second event sampling.		
Case III:		
Fail to reject H_o	Reject H_o	Reject H_o
There is no size/sex selectivity detected during the second event but there is during the first event sampling.		
Case IV:		
Reject H_o	Reject H_o	Either result possible
There is size/sex selectivity detected during both the first and second sampling events.		
Evaluation Required:		
Fail to reject H_o	Fail to reject H_o	Reject H_o

Sample sizes and powers of tests must be considered:

A. If sample sizes for M vs. R and C vs. R tests are not small and sample sizes for M vs. C test are very large, the M vs. C test is likely detecting small differences which have little potential to result in bias during estimation. *Case I* is appropriate.

B. If a) sample sizes for M vs. R are small, b) the M vs. R p-value is not large (~0.20 or less), and c) the C vs. R sample sizes are not small and/or the C vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the second event which the M vs. R test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

C. If a) sample sizes for C vs. R are small, b) the C vs. R p-value is not large (~0.20 or less), and c) the M vs. R sample sizes are not small and/or the M vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the first event which the C vs. R test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for C vs. R and M vs. R are both small, and b) both the C vs. R and M vs. R p-values are not large (~0.20 or less), the rejection of the null in the M vs. C test may be the result of size/sex selectivity during both events which the C vs. R and M vs. R tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation.

Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

If stratification by sex or length is necessary prior to estimating composition parameters, then an overall composition parameters (p_k) is estimated by combining within stratum composition estimates using:

$$\hat{p}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik} \text{ ; and,} \tag{1}$$

$$\hat{V}\left[\hat{p}_k\right] \approx \frac{1}{\hat{N}_\Sigma^2} \sum_{i=1}^{j} \left(\hat{N}_i^2 \hat{V}\left[\hat{p}_{ik}\right] + \left(\hat{p}_{ik} - \hat{p}_k\right)^2 \hat{V}\left[\hat{N}_i\right] \right). \tag{2}$$

where:
j = the number of sex/size strata;
$\hat{p}_{ik}$ = the estimated proportion of fish that were age or size k among fish in stratum i;
$\hat{N}_i$ = the estimated abundance in stratum i; and,
$\hat{N}_\Sigma$ = sum of the $\hat{N}_i$ across strata.

Appendix D2.–Tests of consistency for the Petersen estimator (from Seber 1982, page 438).

TESTS OF CONSISTENCY FOR PETERSEN ESTIMATOR

Of the following conditions, at least one must be fulfilled to meet assumptions of a Petersen estimator:

1. Marked fish mix completely with unmarked fish between events;
2. Every fish has an equal probability of being captured and marked during event 1; or,
3. Every fish has an equal probability of being captured and examined during event 2.

To evaluate these three assumptions, the chi-square statistic will be used to examine the following contingency tables as recommended by Seber (1982). At least one null hypothesis needs to be accepted for assumptions of the Petersen model (Bailey 1951, 1952; Chapman 1951) to be valid. If all three tests are rejected, a temporally or geographically stratified estimator (Darroch 1961) should be used to estimate abundance.

I.-Test For Complete Mixing[a]

Area/Time Where Marked	Area/Time Where Recaptured				Not Recaptured
	1	**2**	**…**	**t**	(n_1-m_2)
1					
2					
…					
s					

II.-Test For Equal Probability of capture during the first event[b]

	Area/Time Where Examined			
	1	**2**	**…**	**t**
Marked (m_2)				
Unmarked (n_2-m_2)				

III.-Test for equal probability of capture during the second event[c]

	Area/Time Where Marked			
	1	**2**	**…**	**s**
Recaptured (m_2)				
Not Recaptured (n_1-m_2)				

[a] This tests the hypothesis that movement probabilities (θ) from time or area i (i = 1, 2, ...s) to section j (j = 1, 2, ...t) are the same among sections: H_0: $\theta_{ij} = \theta_j$.

[b] This tests the hypothesis of homogeneity on the columns of the 2-by-t contingency table with respect to the marked to unmarked ratio among time or area designations: H_0: $\Sigma_i a_i \theta_{ij} = kU_j$, where k = total marks released/total unmarked in the population, U_j = total unmarked fish in stratum j at the time of sampling, and a_i = number of marked fish released in stratum i.

[c] This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities among time or area designations: H_0: $\Sigma_j \theta_{ij} p_j = d$, where p_j is the probability of capturing a fish in section j during the second event, and d is a constant.

Table D2-1.-Anticipated sampling rates and sample sizes necessary to estimate abundance within ±25%, 90% of the time using a Darroch model (or ±12.5% using a Petersen model) and adjusting for 25% and 15% loss of marked fish.

Population Size (N)	marks deployed	mark loss	valid marks	2nd Event sample needed	2nd Event sample % of N
120,000	700	25%	525	29,928	24.94%
100,000	700	25%	525	24,924	24.92%
80,000	700	25%	525	19,919	24.90%
60,000	700	25%	525	14,915	24.86%
40,000	700	25%	525	9,910	24.78%
20,000	700	25%	525	4,905	24.53%
120,000	700	15%	595	27,193	22.66%
100,000	700	15%	595	22,643	22.64%
80,000	700	15%	595	18,094	22.62%
60,000	700	15%	595	13,544	22.57%
40,000	700	15%	595	8,994	22.49%
20,000	700	15%	595	4,444	22.22%

Table D2-2.-Anticipated sampling rates and sample sizes necessary to estimate abundance within ±40%, 90% of the time using a Darroch model (or ±20% using a Petersen model) and adjusting for 25% and 15% loss of marked fish.

Population Size (N)	marks deployed	mark loss	valid marks	2nd Event sample needed	2nd Event sample % of N
120,000	600	15%	510	14,414	12.01%
100,000	600	15%	510	12,003	12.00%
80,000	600	15%	510	9,592	11.99%
60,000	600	15%	510	7,180	11.97%
40,000	600	15%	510	4,769	11.92%
20,000	600	15%	510	2,357	11.79%

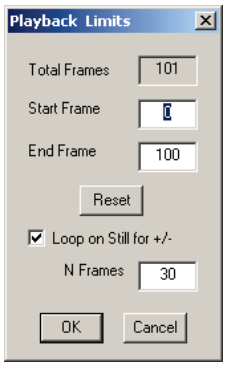
APPENDIX E

Appendix E1.–Instructions and settings for manual length measurements using Sound Metrics Software Version 5.25.11 (or higher if a version with bug-fixes or needed features is subsequently released).

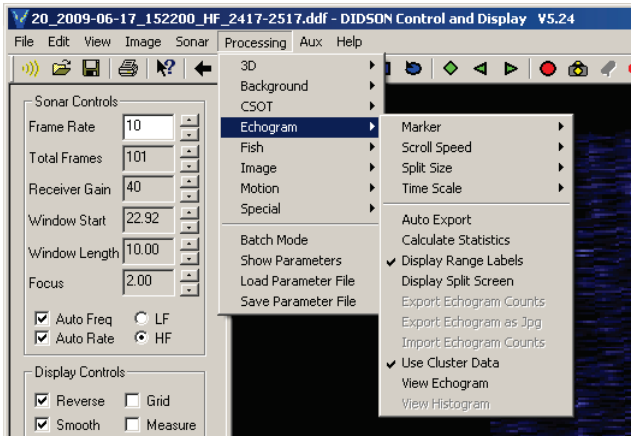
Parameter setup prior to beginning measurements:

Step 1. set the number of frames displayed (i.e., when right-clicking on a fish in echogram mode to display in movie mode) from the default of plus minus one second to +- any number of frames:

1. Select **<image><playback><set endpoints>**
2. [√] Loop on still for +/- N frames
3. Enter the number of frames (I suggest 20-30) but you be the judge



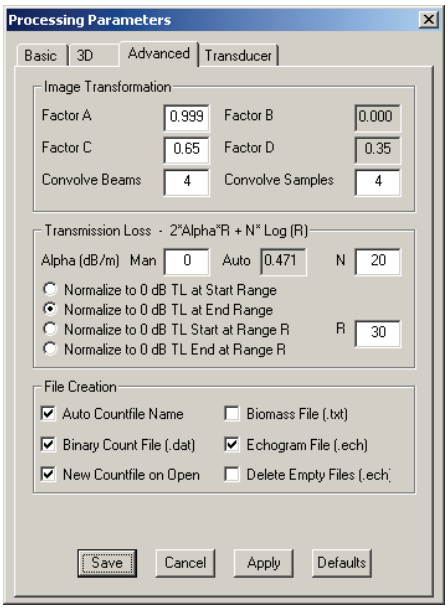
Step 2. Select **<Processing><Echogram><Use Cluster Data>** if you want to use ALL the beams when creating your Echogram (we generally do). You can use fewer beams by unchecking this option and going to the



Step 3. Set up your **processing parameters** (last Icon on right) for **<u>File Creation</u>** as follows:

- ✓ Auto Countfile Name
- ✓ Binary Count File (.dat)
- ✓ New Countfile on Open
- ✓ Echogram File (.ech)

! DO NOT check Biomass file or Delete Empty Files



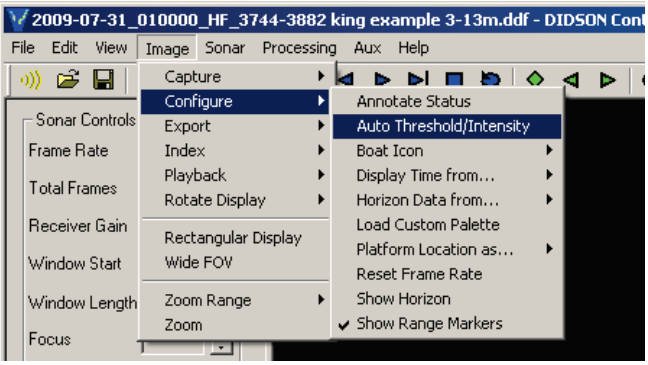
Step 4. You can reload your Echogram counts to finish at a later time if you have checked the Echogram file as follows:

1. Select **<File><Open> then Files of type .ech** from drop-down menu
2. Open desired file
3. The Echogram should reload showing you your previous measurements

Or this option will work as long as you saved the .dat file (as shown above)

1. Open the file and bring up your echogram as usual (follow instructions below)
2. Select **<Processing><Echogram><Import Echogram Counts>**
3. Select the **.dat** file with your saved counts – file should reload showing you your previous measurements (the filename for the .dat file will begin with **FC_**)

Step 5. Make sure <Image><Configure><Auto Threshold/Intensity> is UNCHECKED! This will keep your threshold and intensity settings from changing when you switch between echogram and movie mode



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Step 6. Uncheck the 'Display Raw Data' toolbar icon (first button on left in Combined toolbar). (If you are in the movie mode and it is displaying the raw image data, it is because 'Display Raw Data' is enabled by default).

Caveats/Tips:

- ✓ Don't forget to ***save your work frequently*** by selecting the [e] key – the first time you do this in each file, it will ask for your initials
- ✓ Try not to use more than 4-5 segments to outline the fish (this may artificially increase the length of the fish) – starting at the snout and following the mid-section of the fish to the tip of the tail
- ✓ Uncheck **<View> <Header>** (or use icon) to increase size of echogram or image

Instructions for manual echogram-based length measurements

***note that these settings may already be active as some of them have "memory" and are saved until changed**

1. Select **<BS>** (for background subtraction) from toolbar - or under **<Processing><Background><Background Subtraction>**
2. Select **<Processing><Background><Fixed Background>**
3. Select threshold and range settings given in Table D1-1 (To adjust these settings, use the slider bars under Display Controls to the left of the echogram).
4. Select **<EG>** (for view Echogram) from toolbar or under **<Processing><Echogram><View echogram**>
5. **<left mouse click>** on the echogram near\on the fish trace of interest to "mark it" - you should see a white circle
6. **<right mouse click>** INSIDE the white circle to switch to movie mode (movie mode will play the 16 frames encompassing this circle continuously)
7. Press **<space bar>** to pause movie
8. Step through the movie frames using the right or left arrows until you find a frame that you think displays the entire length of the fish well (see section below on selecting optimal images).
9. **<right mouse click drag>** will magnify the area in the rectangle
10. **<left mouse click>** on the FISH SNOUT and continue to <left click> along the body to create a "segmented measurement." ***The segments should follow the midline of the body of the fish*** – ending with the tail. Try not to use more than three or four segments to define the fish (Figure D1-2,)
11. **<double left mouse click>** or select **<f>** key to add measurement to file (fish it!)
12. **<right mouse click>** to unzoom
13. **<right mouse click>** to return to Echogram

Hot keys:

1. **<e>** to "save" your echogram measurements to file
2. **<f>** to "fish it" (enter it in the text file of measured fish)
3. **<u>** to "undo" the last segment
4. **<d>** to "delete" the all segments
5. **<space bar>** to pause in movie mode (if this doesn't work – click in the black area of the display)
6. **<right arrow>** forward direction when you select play or advances frame one at a time if the pause button is on (pause button = blue square on the toolbar)
7. **<left arrow>** opposite of above
8. **Left Mouse Click Drag –** to show movie of the selected fish
9. **Right Mouse Click Drag –** zooms the selected area

Table D1-1.-Threshold and intensity settings for range strata. To adjust these settings, use slider bars under the Display Controls to the left side of the Echogram or Movie window.

	3.3-8.3m	8.3-13.3m	13.3-23.3m	23.3-33.3m
Threshold	11	11	10	9
Intensity	50	50	45	40

Selecting optimal images to measure

Measurements should be taken from frames where contrast between the fish image and background are high and where the fish displays its full length (e.g. Panels a, d, and f in Figure E1-1). In general, the best images are obtained when the fish is sinusoidal in shape (rather than straight and perfectly perpendicular) because the head and tail appear most visible when there is curvature to the fish body (e.g. Figure E1-2). Figure E1-2 demonstrates the process of measuring a fish using the manual measuring tool. The user pauses the DIDSON movie (top), zooms in on the fish of interest (middle), and measures the fish length with a segmented line created by mouse clicks along the center axis of the fish (bottom). The first mouse click is made at the leading edge of the pixel associated with the snout and the final click on the trailing edge of the pixel associated with the tail. The software adds the individual segment lengths that are calculated from the pixel coordinates of the DIDSON image.

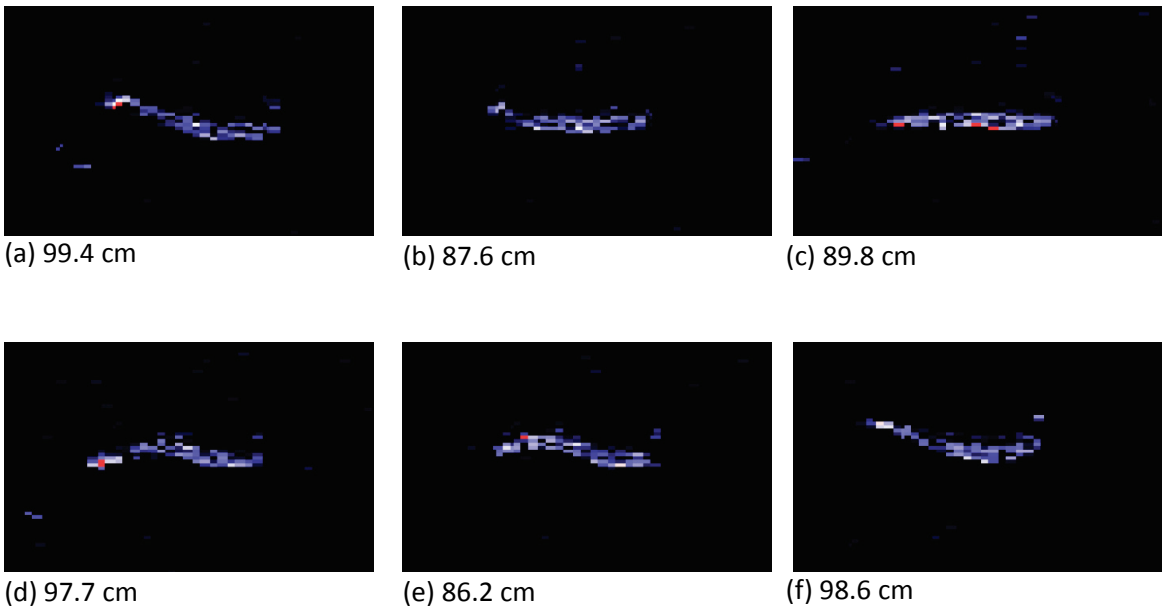

Figure E1-1. – Panels a-f show the variability in length measurements from DIDSON images of a tethered Chinook salmon during one full tail-beat cycle (adapted from Burwen et al. 2010).

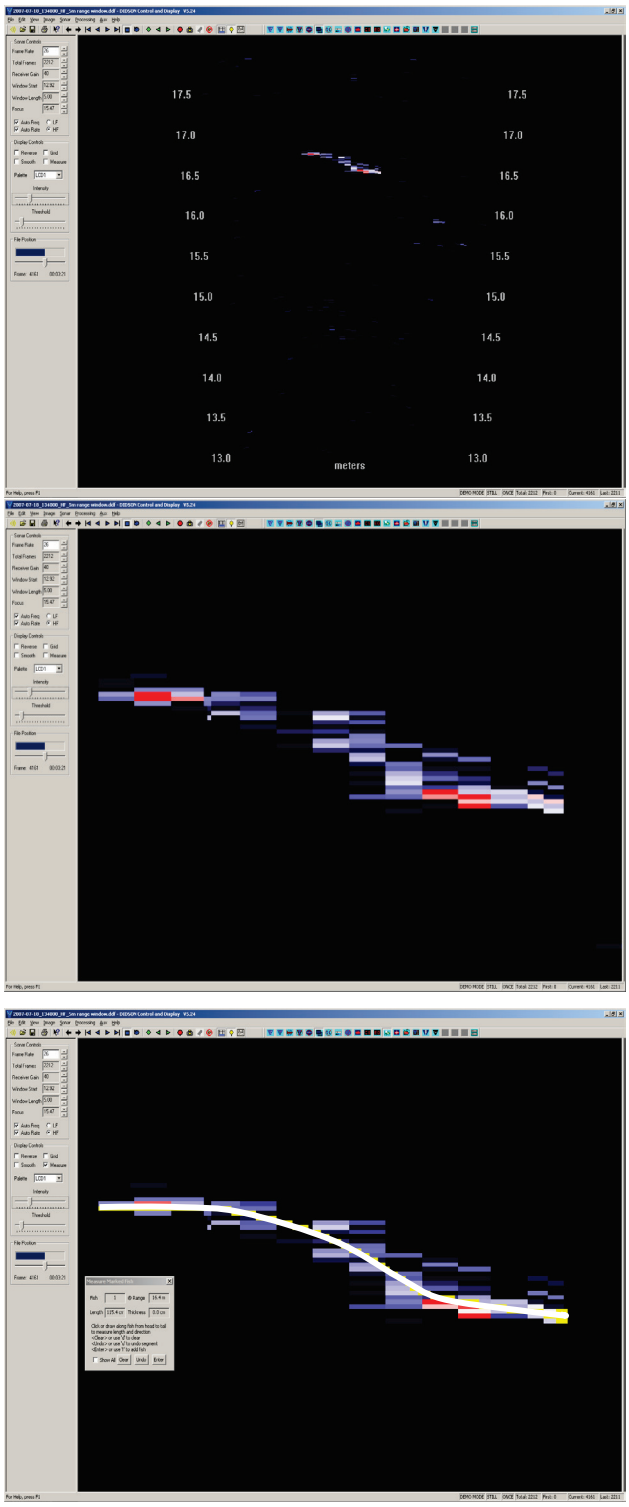

Figure E1-2. – DIDSON images from a tethered Chinook salmon showing the original DIDSON image (top), the zoomed image (middle), and the segmented lines that result when the observer clicks along the length of the fish to mark its length (bottom). Adapted from Burwen et al. 2010.